

XI. A COMPARATIVE STUDY OF SOME SUBFOSSIL REMAINS OF BIRDS FROM BERMUDA, INCLUDING THE "CAHOW."

BY R. W. SHUFELDT.

(PLATES XVI-XXXI.)

My interest in the extinct avian fauna of the Bermudas was aroused through receiving the following communication from Dr. F. A. Lucas, Director of the American Museum of Natural History, New York City, dated August 10, 1915: "I had intended writing you a little while ago in regard to a collection of bones of the extinct Cahow of the Bermudas. We have quite a number of these bones that were given us some time ago, and we agreed to pick out a series for the donor. This Mr. Miller has never found time to do, and I wonder if you would be willing to go over the collection for the sake of studying the anatomy of this extinct petrel and pick out a series for us? If this is asking too much, do not hesitate to say so." In reply to this letter, I said, in effect, that I would welcome such an opportunity to study material of that kind; and, further, I would do all he requested in his communication and be glad to work up the entire collection for publication. A brief correspondence promptly followed, terminating in bringing the collection referred to before me at my home, 3356 Eighteenth Street, Washington, D. C.

On the twenty-third of August, 1915, Doctor Lucas wrote me: "I think that Richmond a few years ago wrote a brief paper on the Cahow, and, as you know, Verrill had quite an article on the subject.

"These particular bones came from a very inaccessible cave in the Bermudas, one that there is good reason to suppose had not been explored before the visit of Mr. McGall.¹ He had great difficulty in getting into the part of the cave where these bones were found, as he had to make a descent by ropes."

These letters are interesting, for, in addition to setting forth Doctor Lucas's view that the bones were from species of birds he believed

¹ Mr Edward McGall, 17 Commerce Street, Orange, New Jersey.

to be extinct, as stated in his first letter, it briefly described the locality where the material was found and who collected it. This resulted in my writing to Mr. McGall, the collector, who shortly afterwards, with great generosity, sent me his own private collection of bones taken in the same caves mentioned above. On the seventh of September, 1915, in a letter I received from Mr. McGall, he said: "A few days ago I sent by express some more bones of this same bird, which were obtained from the cave this year. I was fortunate enough to find vertebræ and other of the smaller bones, so that with this addition you will probably have sufficient to make a presentable assembly. Along with the bones were inclosed a small package of decomposed coral stone and a stalactite. The cave is formed entirely of this decomposed coral sand with stalactite roof. You will note that the stalactite is dead and that the bones have kept in such fine shape because of the dryness of this cave. It is also interesting to note that in all of the other caves visited, some eight in all, no bones of any sort were found. Most of these caves were still damp and stalactite and stalagmite were growing."

"As regards the horizon, I should say that it is entirely recent, approximately three hundred years."²

Being desirous of bringing together all the material possible to work up these most interesting bones, I soon ascertained that, about two years previous to my receiving the two lots referred to in the letters of Doctor Lucas and Mr. McGall, the U. S. National Museum had in its collections some more material, which very likely was of the same character. Upon due investigation it became evident that this material had, for some purpose or other, been sent to the American Museum of Natural History for examination, and probably was in the possession of Doctor Lucas. After a little interesting corre-

² In addition to the bird bones which made up Mr. McGall's collection, I found the claw of some medium-sized crustacean; and, believing that it might prove of interest to identify the species, I submitted the specimen to Miss Mary J. Rathbun, the well-known carcinologist of the U. S. National Museum, who kindly pronounced it to be "a sub-fossil movable finger of *Gecarcinus lagostoma* M. Edw." Miss Rathbun further stated that while "The species is recent, it was not known to live in Bermuda." In other words, this was a part of a claw of a crab, the distribution of which at one time included the Bermudas, but which now is extinct there and probably over still more of its former range.

spondence, he kindly placed that material before me likewise.³ It was received and receipted for by me on the first of November, 1915, and it will be listed beyond. Two days thereafter I received the following communication from Doctor Lucas: "I am very glad to be able to report to you that the bones of the Cahow (*Æstrelata*), from Bermuda, which were forwarded us in December, 1913, by the United States National Museum for purposes of comparison, have been found, and they were sent to you a few days ago. I trust they will reach you safely.

"I am enclosing herewith, for your information, the correspondence relating to the transmittal of the specimens, together with the remarks of Doctor Richmond and Doctor Stejneger on the bones of this interesting bird. It is really very good of you to go into this matter so thoroughly."

The correspondence referred to consists of the usual letter of transmittal, signed by the Assistant Secretary in Charge of the National Museum, and (2) the "Invoice of Specimens" for "Examination," dated November 29, 1913, consisting of "*Æstrelata*" "Cahow," from "Bermuda," collected by "L. L. Mowbray" (No. 223888, "numerous bones").

I have the kind permission of Doctor Stejneger and Doctor Richmond to publish the interesting letters they transmitted at the time. The earliest communication is from Dr. C. W. Richmond, Assistant Curator of Birds, U. S. National Museum, and is addressed to Dr. F. W. True, being dated November 29, 1907. It reads as follows: "I beg to offer the following remarks on the bones of the 'Cahow' presented to the Museum by Mr. Mowbray:

"The material consists of a fragmentary skull, portions of two upper mandibles, fragments of pelvis and sacrum, and of the sternum and pectoral arch, and the following single bones: humerus (6), tibia (3), fibula (1), radius (2), ulna (1), femur (2), metatarsus (1), metacarpus (2), coracoids (2), digits (3), besides several fragments of smaller bones (ribs, etc.).

"Although we have no bones of the West Indian species for com-

³In his letter of October 29, 1915, he says: "I have been overwhelmed with work since returning from my vacation, but will drop a line to say that the *Puffinus* material you have naturally been clamoring for turned up yesterday. I sent out a S.O.S. call and it was found. Shall be sent to you promptly."

parison, the skull and mandibles prove the Bermuda bird to have been one of the genus *Æstrelata*. I have carefully compared certain bones (metatarsus, radius and ulna, and mandibles) with skins of *Æ. caribbæa* and *Æ. hasitata*, the only species known to occur in or near the West Indies, and find them to agree very closely in length with the corresponding bones of *Æ. caribbæa* (as nearly as I can make them out through the skin and feathers). A comparison with the skin of *Æ. hasitata* proves that they are too short for that species. The bones found by Mr. Mowbray, therefore, belong to a species probably identical in size with *Æ. caribbæa*, but the color of the 'Cahow,' as described by the early colonists of Bermuda, differs from the Jamaica Petrel (*Æ. caribbæa*) in having the wings russet and white, with a russet back and white belly. The Jamaican bird is sooty brown with blackish head, wings, and back, and whitish or ashy upper tail-coverts. Russet is a color unknown in this genus, and, so far as known, in the family. Mr. Mowbray told me, however, that he had found one or two russet feathers among the remains taken from the cave in Bailey's Bay, which apparently confirms the statements of the early colonists, and would indicate the "Cahow" to be a distinct species of *Æstrelata*, now extinct, and not yet provided with a name.

"The habits of the 'Cahow' are well described by Butler, Strachy, Hughes, and others, as given by Verrill (*Trans. Conn. Acad. Sci.*, XI, 1902, 668-677), but unfortunately I have been able to find nothing of importance on the habits of either *Æ. caribbæa* or *Æ. hasitata*.

"Very respectfully,

[Signed] CHAS. W. RICHMOND."

On December 1, 1907, Doctor Stejneger sent the following "Memorandum" to Dr. F. W. True:

"Dr. Richmond's note is interesting enough to deserve publication. I do not believe, however, that his conclusion as to the specific distinction of the 'Cahow' based on the *russet* color is well founded. As he says correctly: 'Russet is a color unknown in this genus,' etc., but he evidently only thinks of *russet* as represented by Ridgway's 'Nomenclature of Color,' pl. iii, fig. 16, but the early colonists of Bermuda certainly did not make such a fine discrimination in the application of the term. As the Century Dictionary says, *Russet* is 'a broad and vague term, formerly applied to various shades of gray

and brown or ash-color, sometimes used restrictively, but in no well-settled sense.' The color of *Æstrelata caribbæa* might well have been described by them as *russet*.

L. S."

This communication was followed by another "Memorandum" from Doctor Stejneger, addressed to Dr. F. W. True, and dated January 2, 1908; it read as follows:

"As requested by you, I have gone over Mr. Mowbray's material with Dr. Richmond, and came essentially to the same result as he, viz., that the bones belong to an undescribed species of *Æstrelata* having the size of *Æ. caribbæa* and the coloration of the somewhat larger *Æ. hasitata*. This of course under the supposition that the bones belong to the 'Cahow' as described by the early colonists. As for the 'russet' color, I am of the belief that the colonists by this designation meant the brownish-grayish color so characteristic of these birds. As Mr. Mowbray is said to have some feathers of a 'russet' color, he may be able to throw some light on this question.

"Dr. Richmond thinks that probably Mr. Mowbray himself might want to publish the matter, as he has only asked the Museum to identify the material.

"Respectfully,

[Signed] LEONARD STEJNEGER."

Doctor Richmond, in his letter of November 29, 1913, set forth above, gives a list of the material representing these subfossil birds of Bermuda belonging to the U. S. National Museum. I find this list substantially correct, so it is unnecessary to duplicate it here; it will be described further on in the present paper.

A short time after the bones from the American Museum of Natural History, and those forming the collection of Mr. McGall, were in my possession, I separated, in the case of both, the various bones into groups, placing all the skulls together, all the vertebræ, all the different long bones, ribs, digits, and so on. After this had been accomplished with the greatest care, I prepared two lists of the material as follows:

LIST OF MATERIAL FROM THE AMERICAN MUSEUM OF NATURAL HISTORY.

- 3 crania (more or less incomplete).
- 3 quadrate bones.
- 3 mandibles and five fragments of others.
- 49 vertebræ (chiefly cervical and dorsal, including three axes, only one caudal vertebra, and no atlas).
- 49 vertebral ribs (all nearly perfect).
- 16 costal ribs (all nearly perfect).
- 6 sterna (one fragment, five nearly perfect).
- 8 sacra (more or less perfect, with ossa innominata for nearly all of them).
- 8 coracoids (five lefts and three rights).
- 9 scapulæ (three lefts and six rights; all very nearly perfect save one, the distal end of which is lost).
- 4 ossa furculæ (fragments of two others).
- 20 humeri (eleven of right limb and nine of the left; all very nearly perfect save two; one right humerus has but the proximal half or rather more):
- 5 ulnæ (three rights, two lefts).
- 17 radii (eight of one side, nine of the other; all nearly perfect).
- 15 metacarpi (nine rights and six lefts; all nearly perfect).
- 6 phalangeal joints (proximal ones of index digits; all very nearly perfect; one of right limb and five of the left).
- 4 distal phalanges (three of pollex and one of index digits).
- 9 femora (five of left pelvic limb and four of the right).
- 12 tibio-tarsi (four of right limbs and eight of the left; more or less perfect).
- 1 fibula (right side).
- 16 tarso-metatarsi (eight from either side; all nearly perfect).
- 5 pedal phalanges.

BONES REPRESENTING A SMALLER SPECIES.

(To be described further on in this paper. Apparently all belonged to the same individual, with the exception of the two tibio-tarsi.)

- 1 cranium (more or less imperfect).
- 4 fragments of a sternum.

- 2 ossa innominata (quite perfect).
- 2 bones of the forearm (left side).
- 1 carpo-metacarpus (left side).
- 2 tibio-tarsi (different individuals; quite perfect).
- 1 tarso-metatarsi (right limb; perfect).

LIST OF MATERIAL IN THE COLLECTION OF MR. EDWARD MCGALL.

- 5 crania (more or less incomplete).
- 5 quadrate bones.
- 3 mandibles and four fragments of others.
- 1 mandible of another species.
- 64 vertebræ (chiefly cervical and dorsal, including one atlas and one axis; four caudals, and six of a smaller species).
- 69 vertebral ribs (including a few imperfect ones).
- 34 costal ribs (including a few imperfect ones).
- 1 *very small* vertebral rib } different species.
- 1 *very small* costal rib }
- 5 sterna.
- 1 sternum of a larger species.
- 7 ossa innominata (no sacrum).
- 3 coracoids.
- 1 coracoid of another species (smaller).
- 8 scapulæ (two rights, six lefts).
- 6 ossa furculæ and three fragments of others.
- 1 broken one of a smaller species.
- 30 humeri (ten rights, twenty lefts; all perfect).
- 5 humeri, smaller species (two rights, three lefts).
- 35 ulnæ (twenty rights, fifteen lefts).
- 3 ulnæ, smaller species (one right, two lefts).
- 33 radii (perfect).
- 1 radius of a smaller species.
- 13 carpo-metacarpi (six rights, seven lefts).
- 1 carpo-metacarpus of a smaller species (right).

PHALANGEAL JOINTS.

- 6 proximal of index.
- 1 proximal of index, smaller species.

11 terminals.

7 femora (three rights, four lefts).

10 tibio-tarsi (five rights, five lefts).

2 tibio-tarsi of another species (one right, one left).

8 fibulæ.

10 tarso-metatarsi (six rights, four lefts).

1 tarso-metatarsus of another species.

42 pedal phalanges (not assorted).

This preliminary going over of the material gave me quite an insight as to its nature, value, and not a few of the characters of the various bones; when, shortly after it had been arranged for study, I received as a loan, through the kindness of Doctor Richmond, the following skeletons and parts of skeletons from the collections of the U. S. National Museum:

LIST OF MATERIAL FOR COMPARISON.

(Existing species.)

1. *Daption capense*. No. 18210. Skull and other bones.
2. *Occanodroma leucorhoa*. Nos. 18077, 18078. Skeletons.
3. *Æstrelata lessoni*. No. 14494. Skull.
4. *Cookalaria cookii*. No. 18285. Skeleton.
5. *Pelecanoides urinatrix*. No. 18771. Skeleton.
6. *Puffinus major*. No. 18076. Skeleton.
7. *Puffinus gavia*. No. 18286. Skeleton.
8. *Puffinus gavia*. No. 19385. Skeleton, trunk.
9. *Puffinus borealis*. No. 17769. Skeleton.
10. *Puffinus griscus*. No. 19386. Skeleton, trunk.
11. *Fulmarus glacialis*. No. 15731. }
12. *Fulmarus glacialis*. No. 15732. } Imperfect skeletons.
13. *Fulmarus glacialis*. No. 15728. }
14. *Fulmarus glacialis*. No. 16781. Skeleton.
15. *Puffinus obscurus*. No. 17724. Imperfect skeleton.
16. *Puffinus creatopus*. No. 18773. Skeleton.
17. *Puffinus borealis*. No. 17767. Skeleton.
18. *Puffinus major*. 17799. Skeleton.

To these were added several skeletons of *Colymbus auritus*, *C. cristatus*, and *Podilymbus podiceps*.

This represented all the material in the collections of the U. S. National Museum which could be of any use whatever in the way of comparison; it is very evident that, in so far as skeletons of *Estrelata* of any species are concerned, it is a long way from being of either the proper kind or in sufficient quantity. This being the case, I at once put myself in communication with other naturalists and institutions with the hope of augmenting it. I was surprised to find how very little material of the kind was to be found in the collections of either private individuals or of institutions. For example, Dr. Frank E. Beddard, F.R.S., Prosector of the Zoölogical Society of London, wrote me on the 12th of October, 1915, to the effect that "I fear that I am of no use to you in the matter of which you write. The collection here of birds' skeletons does not include the types you require. I am sorry not to be able to help you." Dr. Arthur Keith, F.R.C.S., Conservator of the Museum of the Royal College of Surgeons of England, in his note of the 11th of October, 1915, said: "I would send you the tracings and drawings with good-will, but unfortunately Mr. Bedone and his assistant—who have charge of the Bird part of the Museum—are in France, and I do not know when they may return. Indeed—at present—the Museum is shut down and only the more urgent work is being carried on. But as soon as my men come back you shall have the facts you are in need of.

"With kindest regards,

"Yours sincerely,

[Signed] A. KEITH."

This kind note spoke only too plainly of the effect of the great European war upon the scientific institutions in London.

As Prof. C. J. Maynard had collected extensively in the Bermudas, I wrote to him with the view of ascertaining whether he had in his collections any skeletons of Petrels and Shearwaters that might be of value by way of comparison in the work in hand. On the 6th of September, 1915, he wrote me from his home at West Newton, Massachusetts to the effect that "I am sorry to have to tell you that I have no complete skeleton of Audubon's Shearwater, but have a sternum which I shall be glad to lend to you if that will be of service to you. It is roughed out, as sternums are best kept in this condition until wanted.

"Very truly yours,

[Signed] C. J. MAYNARD."

This was followed by a postal card, dated September 10, 1915, upon which he said: "I am sending you the Audubon Shearwater sternum by this mail. Yes, it is a perfect sternum, shoulder-girdle and all. This was, and still is, my method of collecting sternums of Aves, of which I have a large number of many species. Shall be glad to see your paper." Finally, Professor Maynard sent me the following letter, under date of September 17, 1915:

"When I collected the Shearwater from which the sternum was taken that I sent to you the species was known as *Puffinus obscurus* Gm. (see Coues Key, 1894, p. 786). I presume that it was then considered the same as the Indian Ocean species. It was, however, separated by Finsch in 1872 and named *P. Auduboni* (P. Z. S., 1872, 111).

"Now it seems, as you say, we must call it *Puffinus lherminieri*.

"You will find an account of the soft parts of a portion of the internal structure in my Birds of Eastern North America, Revised Edition 1897, p. 35. This book is, I think, in the Smithsonian or National Museum library.

"Did I tell you in my last that I shall be glad to have you clean that sternum? I intended to have done so, if I did not.

"I shall be pleased to read your opinion regarding the identity of the "Cahow" of Bermuda in your forthcoming paper.

"If I do go to the Bahamas this coming spring I will try and get a skeleton or two of Audubon's Shearwater.

"Very truly yours,

[Signed] C. J. MAYNARD."

Desiring to measure the wing and leg bones in the case of certain petrels as best I could, and having been informed by Doctor Richmond that Prof. Leverett M. Loomis, of the California Academy of Sciences, had had in his possession for study for a very long time the unique skins of *Æstrelata caribbæa* and *Æ. hasitata*, I wrote him, requesting him to obtain the aforesaid desired lengths of the ulnæ and tarso-metatarsi for me. The skins in question belonged to the U. S. National Museum, and are of particular value, as it is very probable that both species are now to be numbered among the extinct birds of America. In reply I received the following communication:

"SAN FRANCISCO, Oct. 16, 1915.

"*Dear Doctor Shufeldt:* "In order that the personal equation may be maintained in your measurements, I will return next week to the National Museum the specimens of *Æstrelata caribbæa*, also the specimen of *Æstrelata hasitata*.

"I think there are several specimens of these birds in the Cory collection at the Field Museum.

"Sincerely yours,

[Signed] LEVERETT MILLS LOOMIS."

A letter from me on the subject to Mr. Cory, addressed to the Field Museum of Natural History, Chicago, brought a reply (Nov. 12, 1915) to the effect that "We have no skeletons or skulls which you ask for, so can not help you out in this matter.

"Very sincerely yours,

[Signed] CHARLES B. CORY,
Curator of Zoölogy."

Believing there might be something I could use in the collection of the Museum of Comparative Zoölogy, at Cambridge, I wrote to Prof. Hubert Lyman Clark in regard to the matter, and the following communication was received from that institution:

"October 4, 1915.

"DR. R. W. SHUFELDT,

"Washington, D. C.

"*Dear Sir:* Answering your letter addressed to Dr. Clark, I regret that our series of specimens does not include any of the species of *Puffinus* or *Æstrelata* that you ask for, though we may have some of these forms in alcohol, and at a later date these alcoholic specimens may be accessible.

"We have a complete skeleton of *Æstrelata lessoni*. If this will be of service in your work, I shall be glad to loan it to you for a short time.

"Yours truly,

[Signed] SAMUEL HENSHAW,
Director."

Replying that I would be very glad to see the skeleton referred to, the following came to hand (Oct. 18, 1915): "I am sending by ex-



press, charges collect, the skeleton of *Æstreclata lessoni*, and I hope it will reach you in good condition and answer your purpose.

"I have delayed the sending that we might examine our alcoholic material. This has now been done, and I regret that we have no specimens of *Puffinus* or *Æstreclata*.

"Yours truly,

[Signed] SAMUEL HENSHAW,
Director."

I was surprised to find that the specimen was a most carefully mounted one,⁴ and I felt all the more grateful for the unusual courtesy extended. At once I compared it with the descriptions of Forbes of *Æstreclata lessoni*, and found that it must have belonged to a much smaller and entirely different species.⁵ This being the case, I wrote Professor Henshaw for particulars, receiving the following reply:

"October 28, 1915.

"DR. R. W. SHUFELDT,
Washington, D. C.

"Dear Sir: Answering your letter in regard to the skeleton of *Æstreclata lessoni*, I regret that the data may not prove wholly satisfactory.

"It was bought by Mr. Agassiz in January, 1884, of Prof. H. A. Ward. The only locality recorded is New Zealand.

"The entry in the catalogue is in the hand of Dr. J. A. Allen.

"Yours truly,

[Signed] SAMUEL HENSHAW,
Director."

Matters having proceeded thus far, I invited Mr. Austin H. Clark, of the U. S. National Museum, to examine the material with me, an

⁴ I have since made a good negative of this bird, and it will be described further on in this paper.

⁵ Forbes, William Alexander. "Report on the Anatomy of the Petrels (*Tubinares*) Collected during the Voyage of H. M. S. *Challenger*," Vol. IV, Pt. XI, p. 1. (Plates XII-XXIV.) See also "The Scientific Papers of W. A. Forbes," pp. 363-440 (plates with same numbers). The skull of "*Æstreclata lessoni*" (3 views) are presented on Plate XXII. It is very considerably larger than the skull of the specimen I received from the Museum of Comparative Zoölogy, which is numbered 1429.

invitation he kindly accepted. In a few days thereafter he submitted me the following communication on the subject, which is valuable, to the point, and here published *in extenso*:

“SMITHSONIAN INSTITUTION,
“UNITED STATES NATIONAL MUSEUM,
“WASHINGTON, D. C.

“November 2, 1915.

“DR. R. W. SHUFELDT,
“3356 Eighteenth St.,
“Washington, D. C.

“*Dear Dr. Shufeldt*: Before reaching a conclusion based directly upon the examination of the bird skeletons from Bermuda which you recently showed me, it is well to review the information at hand regarding the comparable elements in the avifauna of the West India islands further to the south, islands in their marine fauna (upon which the sea-birds are dependent for their existence) not essentially different from Bermuda.

“Aside from the shore-birds and gulls, gannets, tropic-birds, etc., which may at once be excluded from consideration, we find that Guadeloupe originally supported at least two, and possibly three, species of shearwaters, (1) *Puffinus lherminieri* (= *Puffinus auduboni* auct.) and (2) *Æstrelata caribbæa* (= *Æstrelata jamaicensis* auct.); certain evidence seems to point to the occurrence of another, white breasted, species of *Æstrelata*, which may have been *Æstrelata hastata*. The famous ‘Diablotin,’ so called from its nocturnal habits and weird cry, and once a very important article of food, was *Æstrelata caribbæa*, or a very closely related form.

“On Jamaica there was the same complex, (1) *Puffinus lherminieri* and (2) *Æstrelata caribbæa*.

“The ‘Pimlico’ of Bermuda (still so called) was *Puffinus lherminieri* (given by Hurdis and Reid as *P. obscurus*), or the first element in the complex of Guadeloupe and Jamaica; and I can see no reason to suppose that your small skeletons are anything else.

“From the very close similarity of the habits of the Cahow and those of the Diablotin as recorded by the naturalists of Guadeloupe it seems almost certain that the former could have been nothing else

than a species of the genus *Æstrelata*, representing the second element in the complex found on Guadeloupe and Jamaica. The larger skeletons seem undoubtedly to be those of a representative of that genus, though which species can not be determined without more abundant material for comparison.

“Verrill does not believe that the Cahow could have been a petrel, but his objections do not seem to me to be very weighty.

“The Cahow usually bred in holes, and not in natural caves and crevices like the Diablotin; this difference in habit is not significant; the Bermuda Bluebird is peculiar in building nests and not laying in holes like other bluebirds; yet I once found a nest in one of the holes in the capstan of a wrecked ship near the Flatts. The Tropic Birds at Bermuda nest in holes, or at least in deep crevices, which is not by any means a universal habit of the allied species farther south. *Puffinus lherminieri* breeds either in crevices or in holes of greater or less depth according to circumstances.

“I see no reason for doubting, as Verrill does, the statement of Governor Butler that the eggs and young of the Cahow were found in crevices of the ledges, though of course I would assume that this was in addition to the usual occurrence in holes.

“The flesh and eggs of the Diablotin at Guadeloupe were just as highly esteemed as food as those of the Cahow at Bermuda; the Diablotin was undoubtedly a shearwater; therefore I can not see the force of Verrill's remarks regarding the West Indian shearwaters that ‘their eggs are so musky that they are not edible; certainly no one would compare them to a hen's egg. Their flesh also has so strong a flavor of bad fish-oil and musk that no one would eat it, unless on the verge of starvation, though the newly hatched young are sometimes eaten by sailors for lack of anything better.’ Barring the fact that styles and tastes in food change just as much as styles and tastes in anything else, and also that the Englishman of the seventeenth century was very far from being so discriminating as the Englishman of the present day, the young of *Puffinus lherminieri* are still sold readily in the West Indian markets wherever they are procurable.

“The color of the Cahow is recorded as ‘inclining to russet, with white bellies, as are likewise the long feathers of their wings, russet and white [1610].’ The ‘russet’ of the present day is a color entirely

unknown among the petrels; but in the sixteenth and seventeenth centuries 'russet' was applied to various shades of gray and brown or ash-color, sometimes used restrictively, though in no well-settled sense. Thus in Florio's 'Worlde of Wordes,' 1598, we find the following: 'Grigietto [grigio (Italian) + diminutive ending], a fine graie or sheepes russet.'

"From the literature there is not the slightest reason to suppose that the Cahow of Bermuda was not a species, though possibly a local and distinctive form, of the genus *Æstrclata*.

"Sincerely yours,

[Signed] AUSTIN H. CLARK."

As Prof. A. E. Verrill was so thoroughly identified with the working out of the zoölogy of the Bermudas, both in the matter of the existing fauna of the islands and with its presumably extinct forms, I made an attempt to get into touch with him in the work I now had fairly under way. My letter eventually reached him, calling forth the following reply:

"NORWAY, MAINE, Oct. 24, 1915.

"*Dear Sir:* Your favor of August 25th relating to Bermuda bird bones interested me very much. I suppose they are the same found by Mr. Mowbray several years ago. I tried at that time to have them sent to some expert osteologist, but could not. Perhaps later ones have been found in the newly discovered caves there. . . . As soon as I return, probably this week, I will see if we have skeletons of the species you wish, if some one else has not already done so. Dr. Geo. Eaton, who is Curator of Osteology, was away of course during college vacation. Whether he is now back I don't know, but presume he is.

"Very respectfully yours,

[Signed] A. E. VERRILL.

"P. S.—We have no fossil bones from Bermuda that would be of use to you. If you lack any of my papers on that subject (Cahow) I can send you copies."

Later on I received the following letter from Mr. W. P. Pycraft, of the British Museum:

“ BRITISH MUSEUM (NATURAL HISTORY),
 “ CROMWELL ROAD, LONDON, S. W.,
 “ 8. XI. 15.

“ *Dear Sir:* Your request for skeletons has been passed on to me, as I have charge of the Osteological collections from birds, up to and including Man.

“ I have no skeletons that I could send out on loan, even if there were no risks attendant on their passage out and home.

“ Neither is it possible to send drawings.

“ Most of my staff are absent in the trenches, and thus it is hard to cope with the ordinary curatorial work of the Department.

“ Yours truly, .

[Signed] W. P. PYCRAFT.”

At this stage of my inquiry I devoted myself to examining some of the previous literature upon the “Cahow,” though it did not seem necessary to enter very exhaustively upon this. It was known to me that Doctor Richmond had gone extensively into this part of the subject; and after having done so, as shown in one of his letters on a previous page of this article, he came to a definite opinion in the premises, that the “Cahow” was an *Æstreclata*. Had I read all the literature gone over by Doctor Richmond, I should, no doubt, have come to precisely the same opinion; others have already done so before me, so there is nothing in particular to be gained by reopening the literary side of the subject.

The early writers did little or nothing with the osteology of the Petrels and Shearwaters of Bermuda; the question of the color (rust) has been thoroughly gone over; the skins of these birds in existence are very few, indeed, in any museum (*Æstreclata caribbæa* and *Æ. hasitata*), and the early ornithologists have left us no exact measurements of them, nor data upon their distribution. However, I have gone over some of the “Cahow” literature with great care; but, though this is interesting and to some degree helpful, the conclusions reached in the present contribution will be based almost entirely upon the actual material at hand.⁶

⁶ I have read the following accounts on the “Cahow”:

Verrill, Addison E., “The Bermuda Islands,” Vol. I, Supplement to the Second Edition. Publ. by the author, New Haven, Conn., 1907, p. 572. *The American Naturalist*, Vol. 38, No. 451, p. 555, 1904.

In summing up the "*known characteristics of the Cahow*," Professor Verrill came to the conclusion that in their combination the species differed from all known birds. (*Pop. Sci. Monthly*, Vol. IX, p. 22, Nov., 1901; also *Ann. and Mag. Nat. Hist.*, Vol. IX, p. 26, Jan., 1902.)

As the skins which were in the possession of Prof. Leverett M. Loomis were at hand (see his letter *antéa*), and also the "Cahow" material belonging to the U. S. National Museum which Doctor Lucas had, there were some comparable characters which could be disposed of at this stage of the examination.

In the latter lot there is to be found the curved, distal extremity of the superior mandible of an adult "Cahow," which is still covered with its horny sheath or mandibular theca; it is the only beak so covered in all the material representing the subfossil bird bones from Bermuda before me. This is important from the fact that it gives the exact *form* of the end of the superior mandible *as in life*.

On November 3, 1915, at the U. S. National Museum, I compared this sheathed piece of an upper mandible of a "Cahow" with the corresponding part in *Æstrelata caribbæa* and in *Puffinus lherminieri* (Audubon's Shearwater). The examination convinced me of the fact that this subfossil, horn-covered piece of the upper bill came from a species of Petrel (*Æstrelata*) rather than from that of a Shearwater (*Puffinus*), as the interval between the independently curved, terminal

Tristram, Rev. Henry B., *Annals and Magazine of Natural History*, IX, No. 49, Jan., 1902.

Jones, J. Matthew, and Goode, George Brown, "Contributions to the Natural History of the Bermudas," Vol. I, Washington, Government Printing Office, 1884, pp. 274, 276. This is an early and very interesting account; it is Part IV of the aforesaid "Contributions," and entitled "The Birds of Bermuda," by Captain G. Saville Reid, F. Z. S., etc. Captain Reid believed the "Cahow" and *Puffinus obscurus* (*Puffinus lherminieri*) to be identical.

Verrill, Addison E., "The Bermuda Islands." An account of their scenery, climate, productions, physiography, natural history and geology, with sketches of their discovery and early history, and the changes in their flora and fauna due to man. With 38 Plates and over 250 cuts in the text. Reprinted from the *Trans. Conn. Acad. of Science*, Vol. XI, with some changes. Publ. by the author, New Haven, Conn., 1902, pp. 249, 256-267, 449. On pages 313, 448 and 449 of this volume, Professor Verrill gives numerous other works treating of the birds of Bermuda in general, and of the "Cahow" in particular—as those of William Jardine, John L. Hurdis, J. M. Jones, G. Saville Reid, D. Webster Prentiss, Lieut. H. Denison, Witmer Stone, and others.

piece and the anterior narial apertures was altogether too short for a Shearwater, while it quite agreed with those parts in *Æstrelata*. The piece, however, is not sufficient to decide, with certainty, as to what *species* of *Æstrelata* it may have belonged in life. It *almost* agreed in size and form with the beak in *Æstrelata caribbæa*, though quite possibly it may have agreed with the same part in some other petrel of that genus *of a different species*. Upon comparing it with other terminal parts of the superior mandible in other specimens of the skulls in the Bermuda collections at hand, I found that it very evidently belonged to a species abundantly represented therein, as will be shown further on in this paper.

A short time before this examination, or upon the 29th of October, 1915, I had made another, which also brought to light some important and interesting results, as compared with those made by Doctor Richmond; I refer to the *skins* of *Æstrelata caribbæa* and *Æ. hastitata*, both species being now probably extinct. Of these skins I examined two of the first named and one of the latter. Each specimen of *Æstrelata caribbæa* had two labels—the original and its duplicate. One of the specimens is a male and the other a female. They are sooty-brown birds with ashy rumps, and were collected on the same day and in the same locality. The original label on the female bird reads: "Edward Newton (2) *Æstrelata caribbæa* ♀, 17. II. 79. Hab. Cinchona Pls. St. Andw. W. Rock, Jamaica," and on the other side "80859." The National Museum label reads: "80859 *Æstrelata caribbæa* ♀, Cinchona Plantations, S. Andrews, W. Rock, Jamaica," and the reverse side: "Edward Newton, Nov. 17, 1879." The labels on the *male* bird are the same, with the exception that the National Museum number is 80860.

Measuring the bones as best I could through the skin in all cases, and disregarding the theca of the superior mandible, I obtained the following results: In the male bird, the *left ulna* has a total length of 9.50 or 9.51 cms.; the left tarsus 3.52 cms.; the length of the skull is 7.00 cms.

In the female bird, the *right ulna* has a length of 9.51 cms.; the right tarsus 3.51 cms.; and the length of the skull seems to be somewhat longer than in the male, having a length of 7.25 cms.

The fact that the skull of the female is slightly longer than that of the male is doubtless due to the fact that, in skinning the bird, the

skull of the former was not cut away as extensively as it was in the male, and therefore was not left as short. For all practical purposes, the ulna measures in length a little over nine and a half centimeters, and the tarso-metatarsus rather more than three and a half centimeters in either the male or the female bird of *Æstrelata caribbæa*.

The specimen I examined of *Æstrelata hasitata* also had two labels, both being alike. On the obverse side we find: "*Æstrelata hasitata* ad., No. 152522. Near Winchester, Virginia, Dr. W. F. Hutchinson"; on the reverse side: "Last of August, 1893. One of a pair (♂ and ♀) picked up near Winchester, Va., after an eastern storm. They were in an exhausted condition."

In this specimen the proximal third of the left ulna is not present. There are glass eyes in the orbits. The right ulna has a length of 11.15 cms.; the right carpo-metacarpus 4.25 cms. (approx.); and the right tarso-metatarsus 4.0 cms.

The lengths of these various bones will be taken up again further on in the present article, when I come to compare them with the corresponding bones in the several lots of the Bermuda specimens at hand.

It will be advisable, in the first place, to critically examine the recent material I have before me for comparison with the Bermuda specimens, in that it may, at the outstart, be decided which part of it will be of assistance and which will not.

I shall take up first the *sternums*, *shoulder-girdle*, and *costal ribs* or *hæmapophyses* of the specimen of *Puffinus obscurus*, loaned me by Mr. C. J. Maynard, and referred to by him in his letter of September 17, 1915 (see *autéa*). There should be no question about the identification here, and Mr. Maynard has the skin of the bird in his private collection. He admits in his letter that it is an Audubon's Shearwater—that is, *Puffinus lherminieri*. This *sternum* and *pectoral arch* are shown on Plate XXII, fig. 33, and on Plate XXIII, fig. 34, and it is, except in one instance, very unlike any sternum or pectoral arch to be found in the Bermuda specimens. *None* of the latter, therefore, represent Audubon's Shearwater (*Puffinus lherminieri*). With respect to the excepted specimen, this latter is here figured on Plate XXII, fig. 29, and on Plate XXIII, fig. 36. This subfossil specimen from Bermuda, which I find in the collection of Mr. McCall, is the sternum of a *Puffinus* larger than *P. lherminieri*, and I shall describe it further on in the present contribution.

Passing to the skeleton marked "*Puffinus obscurus*" (No. 17724 of the collection of the U. S. National Museum), here shown on Plate XXII, fig. 28, and Plate XXIII, fig. 35, it is at once evident that it belonged to a very different bird from Mr. Maynard's *Puffinus obscurus*. It is the only skeleton of the kind in the collection of the U. S. National Museum; and, as the species is not represented among the subfossil bones from Bermuda, it may therefore be set aside to be used further on in the present connection. Before doing so, however, I will say that the skull of this specimen, although evidently not of the same species, agrees in many particulars and characters with the skull of the "*Æstelata lessoni*" from the Museum of Comparative Zoölogy of Harvard University. (See Pl. XVI, fig. 6; Pl. XVIII, fig. 16; and Pl. XXXI, fig. 126.) Coues, in the Fifth Edition of his "Key," gives the length of the "tarsus" as 1.60 in *Puffinus auduboni* (= *P. lherminieri*); and I find that the metatarsus of this "*P. obscurus*" skeleton (No. 17724, Coll. U. S. Nat. Mus.) measures in length but 1.50 (inches). Still, it is a very much smaller bird, with entirely different sternum from the *Puffinus obscurus* in the Maynard collection; fortunately neither agree with any of the Bermuda specimens.

Among these Petrels and Shearwaters we find sterna of two kinds, namely, one in which the *body* is nearly square in outline, when viewed directly from above or from below. Such sterna may be either large or small. (Compare figures on Plates XIX-XXIII.)

There is a skeleton of "*Puffinus gavia*" in the collection of the U. S. National Museum (No. 18286) which is from a bird of about the same size as No. 17724 ("*P. obscurus*") and with many of its characters in agreement; but it is not the same species, as is at once evident upon a casual comparison.

A typical Shearwater is seen—in so far as its skeleton is concerned—in the mounted one of *Puffinus borealis* of the U. S. National Museum collection (No. 17772).⁷

Taking into consideration what we have up to this point, it is perfectly safe to say, after comparing the specimens with all the subfossil bones in the three lots of the Bermuda material, that Audubon's Shearwater (*Puffinus lherminieri*) is not to be found among them.

The cranium marked "*Æstelata lessoni*," No. 14494, U. S. Nat.

⁷ Shufeldt, R. W., "On the Osteology of the Tubinares." *Am. Nat.*, Vol. XLV, No. 482, Feb., 1907, fig. 1, p. 116.

Mus. Coll., collected by Doctor Kidder (see list above), agrees, in all essential particulars, with the cranium figured by Forbes, as set forth above; doubtless the former came from a specimen of that species, as did likewise the latter. The mounted skeleton from the Museum of Comparative Zoölogy, marked *Æstreclata lessoni*, is not a skeleton of that species, but evidently belonged to some medium-sized Shearwater (*Puffinus*) of a somewhat larger size than *Puffinus lherminieri*. It came from a bird of about similar proportions to the one marked *Puffinus obscurus* of the collection of the U. S. National Museum (No. 17724). The skulls are of the same size and very much alike; but the National Museum specimen had a somewhat longer humerus and a shorter sternum. The species—whatever it was—is not represented in the Bermuda specimens at hand for description.

Æstreclata lessoni is a large, rather heavy Petrel of about the same proportions as *Fulmarus glacialis*, and its skull agrees in many particulars with that species. (Compare with No. 16781, Coll. U. S. Nat. Mus. = *Fulmarus glacialis*.)

Finally, I have compared all the Bermuda specimens with the material in the above list, representing the osteology of the *Tubinarcis* in the collection of the U. S. National Museum, including even *Procellaria cooki* (Pl. XIX, fig. 17) and *Pellicanoides urinatrix* (Pl. XX, fig. 21). Most of this material is likewise figured on the plates; and, as far as it goes, it demonstrates very completely that none of the species are to be found among those from Bermuda, as represented by the bones at hand.

I now pass to a description of the material itself—the subfossil bird bones from Bermuda.

This, as pointed out above, is divided into three (3) lots, and may be designated as:

1. The Mowbray collection.
2. The McGall collection.
3. The American Museum of Natural History collection.

1: In the Mowbray collection the bones are very fragile; have more of the cave incrustation upon them; and are, as a rule, not nearly as perfect as those in the other two lots. It contains no skulls, only a parafin cast of one of the "Cahow" skulls found in the other two collections. The piece of the upper mandible with the theca still upon

it has already been described on a former page. There are 4 humeri in fairly good condition; 2 nearly perfect ulnæ, also 2 ossa quadrata. All of these bones belong to the "Cahow," and need not be referred to especially again, as there is ample duplicate and far more perfect material in the other two collections for the purposes of description.

2: This is the most extensive collection of the three; not only does it contain a large representation of the bones of the "Cahow" in excellent condition, but also the *sternum* of a new species, and a lot of bones representing some smaller tubinarine form—both of which, together with the "Cahow" bones, will be described in detail further on.

3: We have here a smaller collection than the last (No. 2), though withal a most interesting and perfect one. It is chiefly made up of the bones of the "Cahow," and of some very important ones of the more diminutive tubinarine species referred to as being found in the McGall collection. It will, on the whole, very materially contribute to the working up of the specimens before me.

I shall first describe the unique *sternum*, referred to as forming a part of collection No. 2.

***Puffinus mcgalli*, sp. nov.**

(Plate XXII, fig. 29, and Plate XXIII, fig. 36.)

[Recent Epoch.]

Based on an almost perfect *sternum* of an adult individual discovered in the bird-bone caves of Bermuda.

The specimen indicates that it belonged to a species of *Puffinus* of moderate size, and probably possessed characters typical of the genus. Judging from the *sternum* sent me by Mr. Maynard (see *antéa* and the plates), it was a considerably larger bird than *Puffinus lherminieri*, as the length of that bone in the first measures—from the anterior tip of the manubrium to the extreme posterior point of the mid-xiphoidal process—5.8 cms., while in the latter this line or distance equals but 4.4 cms. From apex to apex of the "coracoidal processes," *P. mcgalli* measures 3.3 cms. and *P. lherminieri* but 2.5 cms. Either of these sterna possesses six articular facets on each costal border for the costal ribs. Upon comparing this *sternum* with the *sternum* of "*Puffinus major*" (No. 18076, Coll. U. S. Nat. Mus.), the latter is seen to be a species very considerably larger than the one here being described. I have also compared it with the sterna

of *Puffinus creatopus*, *P. borealis*, *P. griseus*, and others, but it departs more or less from each and all of them.

There is a trunk skeleton of a Shearwater in the collection of the U. S. National Museum (No. 19385) marked "*Puffinus gavia*, San Diego, Cal." Sharpe, in his "Hand-List" (Vol. I, p. 124), restricts the range of this species to "New Zealand and Australia"; it is not listed in the A. O. U. Check-List (1910).

This "*P. gavia*" was a bird of almost exactly the same size as *Puffinus mcgalli*, and its sternum, measured as above, has a length of 5.6 cms., while its width, measured as above, equals 3.45 cms.

McGall's Shearwater possessed a pair of deep "notches" upon either side of the keel, the outer one, on either side, being double the width or more of the one between it and the mid-xiphoidal prolongation. This is likewise the case in the sternum marked *Puffinus gavia* of the National Museum collection (No. 19385).

The very small manubrium in McGall's Shearwater is longitudinally keeled upon its median ventral aspect, while the ventral edges of the coracoidal grooves are carried out upon it laterally to points near its blunt apex. The *coracoidal grooves* are extensive, and they do not meet in the median line behind the manubrial process.

The bone is non-pneumatic, and dorsally the body is profoundly concaved, being correspondingly convex upon its ventral aspect.

Unfortunately, the anterior *carinal angle* of the keel is broken off and lost; but there is no question as to the form it had in life, for it doubtless agreed with what we find in all other Shearwaters of this genus—that is to say, it is somewhat produced anteriorly, expanded from side to side to some considerable degree, compressed from above, downwards, and has, in the articulated skeleton, the os furculum resting upon it. The anterior border of the carina of this Shearwater is thickened above, gradually tapering to the carinal angle below; longitudinally, from above, downwards, it is marked by a well-defined groove.

Costal processes are broadly quadrilateral in outline, and each one rises to a moderate height above the costal groove of its own side. Either costal groove has a length of 1.8 cms., there being five (5) quadrilateral concavities formed by the six (6) transverse, thin, articular facets upon either side.

The lower border of the keel is nearly straight, and it is continued

to the extreme posterior end of the mid-xiphoidal process, gradually diminishing in depth for its entire length. The xiphoidal processes have already been described above.

On either side, posterior to the costal border, the margin of the bone is very thin and sharp. On the ventral aspect of the body the "pectoral line" is very distinct, either one being carried from a mid-point below the coracoidal groove backwards and inwards to a point next to and about at the middle of the keel.

This extinct species is named for Mr. Edward McGall, in recognition of his success in obtaining this valuable collection of fossil bird-bones from Bermuda.

***Puffinus parvus*, sp. nov.**

(Plate XXIV, figs. 43-45; Plate XXV, figs. 55, 56; Plate XXVI, figs. 67, 74, 76, 77, and 79; Plate XXVII, fig. 93, and Plate XXVIII, figs. 101, 107, 121, 122, and 123.)

[Recent Epoch.]

Among the bones in the collection of the American Museum of Natural History, as well as among those in the McGall collection, I find abundant evidence pointing to the fact of the existence of a small Shearwater, now extinct, but which doubtless existed during the times when the countless numbers of the "Cahow" flourished upon certain of the smaller Bermudan islands.

In the first-named collection, there are of these bones a cranium (somewhat imperfect), an ulna, a radius, a carpometacarpus, part of a sternum, four ossa innominata, a femur, a tibiotarsus and a tarsometatarsus; in the latter collection, five perfect humeri, three ulnæ, a radius, a carpometacarpus, a proximal joint of index digit, a coracoid, an inferior mandible, an imperfect os furculum, a tarsometatarsus, and an os innominatum of the left side.

These bones indicate a Shearwater (*Puffinus*) smaller than Audubon's Shearwater (*Puffinus lherminieri*)—that is, smaller than any Shearwater in our present Atlantic Ocean avifauna. It was a smaller *Puffinus* than the one shown in Plate XXIX, fig. 126, of the present paper.⁸

⁸ Upon comparing a number of the bones of this extinct Shearwater with the corresponding ones in the mounted skeleton from the museum referred

Clearly, then, in so far as skeletal material representing Audubon's Shearwater (*P. lherminieri*) is concerned, I have at hand but the sternum and shoulder-girdle from the Maynard collection and the disarticulated skeleton of a "*Puffinus obscurus*" (No. 17724, Coll. U. S. Nat. Mus.) to use as representing that species; the value of these will be touched upon further on.

Upon comparing the cranium of this small Shearwater belonging to the collection of the American Museum of Natural History, I find that it essentially agrees in all particulars, apart from the matter of to, I find that, apart from the matter of size, they possess identical characters. This applies especially to the mandible, the humerus, the radius and ulna, the carpometacarpus, the pectoral arch, the os innominatum, and the bones of the pelvic limb. The extinct bird had a short sternum, however, as in *Puffinus creatopus* and other species, while that bone in the aforesaid mounted skeleton is of the elongate variety, as in *Puffinus major* and others.

There is no doubt about this mounted skeleton from the Museum of Comparative Zoölogy of Harvard University having belonged to a Shearwater (*Puffinus*) of rather small size, though typical of the genus. It was probably incorrectly identified at Ward's Natural Science establishment at Rochester. A paper envelope is attached beneath its stand, in which there are two of the usual printed Ward's labels. In filling in the name in writing on each of these, an error was made in either instance. In one it reads: "Procellaria Lessoni (White-headed Petrel). East coast, New Zealand," and in the other: "Procellaria Lessonii (White-headed Petrel), New Zealand." No further comment is required.

⁹ This cranium, when sent to me with the collection, was carefully packed in a small box by itself and placed *under* all the other packing for all the other bones. Owing to this fact, I did not discover its presence until I came to repack the collection for its return to the Museum, when much to my surprise, it was in the bottom of the original box, hidden from sight by a great quantity of "imperial" or "excelsior." Had I had it with the rest of the bones, it would have been duly figured upon one of the plates; as it is, Figs. 6 and 16 will have to stand for it, only they are somewhat larger. I would take this cranium to be one that belonged to an Audubon's Shearwater—it being either a female or a subadult individual—were it not for the fact that all the other bones in the combined collections, representing *Puffinus parvus*, evidently belonged to a number of different specimens, *all* of which were adult, and *all* smaller in proportion, as compared with the corresponding bones in *Puffinus lherminieri*. Indeed, this skull coming to light in the way it did, and at the time it did, convinces me all the more that, when Audubon's Shearwater and other allied forms were to be found on the Bermudas in enormous numbers, there was also present there this smaller form,—that is, *Puffinus parvus*. (Dec. 10, 1915.)



size, with the cranium of Audubon's Shearwater (Pl. XVI, fig. 6; Pl. XVIII, fig. 16).⁹ It has the same well-marked median furrow on the superior aspect between the frontals posteriorly, and the same, very narrow though rather deep, supraorbital glandular depressions—which are only separated from each other by 2.5 mm.—in the frontal region between the orbits on the top of the cranium.

The superior mandible is slender and the external narial apertures elongate and narrow. Distally, it is decurved, especially enlarged, and ends with an acute, sharp-pointed apex. The interorbital septum presents unusually large vacuities, and the *pars planæ* are very small, projecting outwards in each case as an independent process. With but slight departures, the characters seen in the osseous structures of the basis cranii are the same as we find them to be in all Shearwaters, and more or less like the corresponding ones in a Petrel of the genus *Æstroclata*. Longitudinally, from the most posterior point in the median line of the supraoccipital prominence to the distal apex of the premaxillary, this cranium measures 6.4 cms., and the transverse diameter, between the tips of the postfrontal processes, equals in width 2.35 cms. In short, this cranium belonged to a small species of a typical *Puffinus*.

Coues gives the length of the tarsus, in the case of *Puffinus auduboni*, as 1.60 (or an inch and six-tenths) (Key, 5th Ed., p. 1036), while the tarsus in the species here being described has a length of but 1.50, or even less in the case of a specimen of that bone found in the McGall collection. It was a much smaller species than the one which furnished the skeleton marked "*Puffinus obscurus*" in the collection of the U. S. National Museum (No. 17724), and Audubon's Shearwater was possibly the *Puffinus obscurus* of Gmelin, certainly so of Coues and other ornithologists of a few years ago. It then became *P. auduboni* of Finsch (P. Z. S., 1872, p. 111). So, the skeleton just referred to (No. 17724) being that of a *very small* Shearwater, it brings the matter to a point where Mr. Maynard would have to show that the sternum and shoulder-girdle he sent me belonged to a specimen of Audubon's Shearwater, now called *Puffinus lherminieri* in the last A. O. U. Check-List. It is a very different sternum from the one belonging to the aforesaid museum (No. 17724), and a much larger bone—too large, it strikes me, for the sternum of Audubon's Shearwater (*Puffinus lherminieri*). If the

skeleton numbered 17724 ("*P. obscurus*") in the collection of the U. S. National Museum is in fact Audubon's Shearwater, then the species here being described is *certainly* a new species as well as an extinct one. Mr. C. Maller collected the specimen of "*Puffinus obscurus*," No. 17724, and he collected it at the "Bermudas." This still further emphasizes the fact that it probably represents the skeleton of an Audubon's Shearwater, and that it was a larger species than the one here being considered. The metatarsal bone in No. 17724 measures in length exactly 1.60 inches, and this agrees with the length of the tarsometatarsus of Audubon's Shearwater as given by Coues and set forth above. With all this evidence and these facts before me, I shall consider for the present that the skeleton No. 17724 is one of *Puffinus lherminieri*, and use it in comparison in the present instance. This will not militate against anything I have set forth above in regard to McGall's Shearwater (*P. mcgalli*), or the use I made of the sternum and shoulder-girdle sent me by Mr. Maynard.

Taken together, and judging from the material before me, the bones representing *Puffinus parvus* probably belonged to three different adult individuals. That this may have been the case is based on the fact that there are in it *five perfect humeri*, or those belonging to *two* specimens and one of a third. There are *two pairs* of tarso-metatarsi, two pairs of ulnæ, and so on. Had there been one less humerus, I should have said that the bones in the combined collections represented *two* adult specimens of *P. parvus*; but the fifth humerus makes it possible that three or more may be represented.

The *mandible* of *Puffinus parvus* is of the V-shaped pattern, with the narrow dentary portions drawn very close together—the symphysis being short and the distal apex sharp-pointed and slightly decurved. There is a small ramal vacuity in the deeper ramal divisions, the side of the jaw upon either hand curving upwards and forwards where it is located. Posteriorly, the articular ends are concaved and very slightly truncated. Mesially, the articular cups for the quadrates support the usual inturned apophyses, with the pneumatic foramen at the apex of each. The extreme length of one side of this mandible measures 5.4 cms.

Turning to the mandible of the specimen of "*P. obscurus*" (No. 17724), I find the characters to be much the same, although there are slight but recognizable differences here and there. For example, the

ramal vacuity is reduced to a mere hair-like slit, and so on. It measures in extreme length 5.9 cms., and so belonged to a larger bird than *P. parvus*.

Os furculum is of the U-shaped pattern, the clavicular limbs being slender and of nearly uniform caliber throughout their lengths. There is a faint hypocleidium on their somewhat thickened union below; it is situated posteriorly and amounts to little more than a low, thin line of bone. The free posterior extremities above are drawn out into sharp-pointed endings, and there is an articular facet on the outer side of each at a few millimeters' distance, posterior to the apex. Such a fourchette is well seen in my figure of *Procellaria cooki*; but in this species the free extremities are not drawn out so far, and the articular facets for the coracoid is better marked (Pl. XXIV, fig. 17). Compare figs. 61, 62, 68, 69, 70, 78, and 79 of Plate XXVI.

There is a perfect *coracoid* (left) of *Puffinus parvus* in the McCall collection (fig. 92, Pl. XXVII), which presents all the characters of that bone as we find them in any coracoid of a typical Shearwater. The axis of its shaft measures 2.3 cms., and the transverse diameter of its sternal extremity 1.55 cms. There is a conspicuous precoracoid process that exhibits a foraminal perforation at its lower part near the shaft. The latter is non-extensive and much compressed antero-posteriorly. With the somewhat prominent acromium, the precoracoid forms, mesiad, a vertically elongate valley of considerable extent, opposite which, on the other side of the bone, the glenoid cavity is seen to be elongated vertically and very shallow.

In the collection of the American Museum of Natural History there are two fragments of a *sternum* which evidently belonged to this extinct Shearwater. These fragments consist of the anterior portion of the bone, and a large part of the left half of the sternal body. They did not belong to the same individual, though to one of similar size; both were adult birds. Barring the difference in size, this sternum of *Puffinus parvus* possessed a form very much like the sternum as we find it in *Puffinus major* (see Pl. XXIII, fig. 38). The manubrium is small and peg-like, and the "coracoidal groves" meet mesially. Ventrally, the thoracic concavity is unusually deep and capacious, a single pneumatic foramen being present in the middle line well within the anterior border of the bone. As usual in *Puf-*

fnus, there are six (6) hæmapophysial facets upon either costal border, the well-marked concavities among them being nearly square in outline. The external xiphoidal processes were broad, and extended outwards as much as backwards—more so even than in *Puffinus major*.

No *sacrum*s of this bird were collected, while a lateral moiety of a *pelvis* possesses all the characters, barring size, which we find in any typical *Puffinus*, as, for example, *P. lherminieri* or *P. major*. (Compare fig. 64, Pl. XXVI, and figs. 85-89, Pl. XXVII.)

Ilium has a length of 4.1 cms. in *P. parvus* and 5 cms. in *P. lherminieri*, while in *P. major* the length is 7.6 cms.;¹⁰ some are a millimeter shorter—probably belonging to female individuals.

There may be some vertebræ among the numerous examples of those bones set aside as belonging to the "Cahow" (*Æ. vociferans*); but I can not pronounce upon that with certainty, as they may be ones belonging to either young or female "Cahows."

Five beautiful specimens of the humerus of *P. parvus* occur in the collection of Mr. McGall, and they each and all belonged to adult birds (figs. 55 and 56 of Pl. XXV). Four (4) of these bones possess a length of 5.9 cms., while the fifth measures but 5.75 cms., and may have belonged to a female bird. Its characters are identical with the corresponding ones in a humerus of Audubon's Shearwater, the latter being a longer and a trifle larger bone. (Compare figures 51-60 of Plate XXV.)

In all Shearwaters the humerus appears to be completely non-pneumatic, the shaft being very straight and more or less compressed in the same plane in which the extremities occur—that is, from anconal to palmar superficies. The "ectepicondylar process" is pointed and is a conspicuous feature of this humerus, while the triangular radial crest is bent, as a whole, towards the palmar side of the bone.

¹⁰ While examining the bones of *Puffinus parvus* I met with several fragments of an interesting shell, the most perfect of these being in the collection of the American Museum of Natural History; four (4) of the other fragments occur in the McGall collection. They are all of the same species, and have been identified for me by Dr. Paul Bartsch, of the U. S. National Museum, as being broken examples of five specimens of *Poecilozonites bermudensis*, Pfr. Doctor Bartsch kindly compared them with specimens in the collection of the U. S. National Museum.

Ulna and *radius* present nothing peculiar beyond their size, being smaller than any bones of the antibrachium that I have ever examined belonging to a typical *Puffinus* (Pl. XXIV, figs. 44 and 45). The *ulna*, as in the case of the humerus, exhibits some slight lateral compression, such as we find in other Shearwaters of existing avifaunæ. The *radius* has a length of 5.4 cms. and is nearly straight.¹¹

Bones of the carpus (*radiale* and *ulnare*) do not occur among the subfossil bones in these collections; they doubtless would be almost identical with those elements as we find them in the wrist of any small, typical Shearwater of the genus *Puffinus*.

Carpometacarpus is straight and possesses a length of 3.3 cms. (Pl. XXVI, fig. 67), while that bone in Audubon's Shearwater has a length of 3.6 cms. (Pl. XXVI, figs. 76, 77). There is a specimen of an imperfect carpometacarpus of *Puffinus parvus* in the American Museum collection, which has a length of but 3 cms., but it belonged to a subadult individual, and plainly shows the divisional lines of the added elements at its proximal end.

Proximal phalanx of *index digit* of this extinct species of Shearwater (fig. 74) agrees better in the matter of form with that bone of the skeleton in some of the larger Shearwaters than it does with that of *P. herminieri*, though only in the matter of being very slightly wider for its length (figs. 71-73). In other respects it agrees in its morphology with that segment of the hand in *Puffinæ* generally.

There may be some terminal finger joints of *Puffinus parvus* in these collections, but they may have belonged to female or subadult specimens of the "Cahow"; so I pass them by. The lists show that a considerable number of these bones are present.

Upon comparing all the bones of *manus* shown in Plate XXVI, figs. 65-67, 71-77, and 80-84, one can gain a very correct idea of the size and characters of that part of the skeleton in *P. parvus* as compared with the corresponding parts in other Shearwaters of various sizes; such comparisons render it quite unnecessary for me to enter upon minutiae in the matter of character descriptions of the hand-

¹¹ Some of the bones on the plates may run somewhat longer or be otherwise larger than is stated in the text. This may be due to my having made them so with the camera and the engravers reproducing them exactly, or to the engravers not getting them the same size as the originals; in any event the sizes and lengths as given in the text are to be relied upon.

bones of the extinct species. This remark also applies to the phalangeal joints of the feet.

Turning the attention next to the lower or *pelvic limb*, several of the long bones are present, the number of them being set forth in the various lists above. (Compare the bones of the different species of *Puffinus* shown on Plate XXVIII.)

A perfect femur of *P. parvus* occurs in the collection of the American Museum of Natural History; it agrees in all respects with the femur of Audubon's Shearwater, as shown in figs. 102 and 103, even to the remarkable bending or bowing of the continuity of the shaft at the juncture of middle and lower thirds. In length it measures two and a half centimeters.

Femora of other Shearwaters are well shown in figs. 104 and 105, as well as in 112 and 113. The shafts of these are not bowed quite as much as in the smaller species; while in the Petrels of the genus *Æstreolata*, whether living or extinct, this bone is not bowed at all, but has a straight shaft as in the extinct Petrel, *Æstreolata vociferans* (figs. 97-100). This is an excellent differential character in proving that the "Cahow" was an *Æstreolata* and not a *Puffinus*, as has long been supposed to be the case.

The *tibiotarsus* of *Puffinus parvus* presents all the characters of that bone, as we find them in existing representatives of that genus of birds. These characters are well shown in figs. 118-120, as compared with the tibiotarsi of other Shearwaters illustrated on the same plate (XXVIII). One of the most striking characters is the enormously developed cnemial process. Comparatively speaking, this is even larger than we find it to be in the big birds of the group, as *Puffinus major* and others. Moreover, this great cnemial extension is not to be found in Petrels, in so far as I have examined them, certainly not in the extinct "Cahow" or *Æstreolata vociferans*. All have the shaft of the bone very straight, however, and this is likewise the case with such forms as *Procellaria cooki* and *Pelecanoides urinatrix*, which birds have the cnemial extension of the tibiotarsus reduced as we find it in *Æstreolata*. (See figs. 20 and 24 of Pls. XIX and XX, respectively.)

As in all small and typical Shearwaters, the *tarsometatarsus* of *Puffinus parvus* was long and comparatively slender (figs. 106 and 107, Pl. XXVIII), it being relatively shorter and stouter in the

Petrels. This is another excellent distinctive character between *Puffinus* and *Æstrelata*. The bone in *P. parvus* is remarkably straight and slender, being longitudinally grooved for tendons both anteriorly and posteriorly, more markedly so in front. The intercondylar eminence is prominent, and the condylar cavities upon either side of it are deep and circular in outline. The *hypotarsus* is short, the inner section of it being twice as long as the outer, which latter is once pierced for tendinal passage. A similar passage is to be found between the two sections, but it is not quite closed posteriorly.

Middle third of the shaft is somewhat compressed from side to side; indeed, the entire bone shows something of this transverse compression—even the trochleæ of the distal extremity. With respect to these, the middle one is the longest, the outer next in length, and the inner one of the three the most elevated. Rather high up on the outer side, we note the usual foraminal perforation for the passage of the anterior tibial artery. The shaft of the bone, proximally, is also twice pierced in the antero-posterior direction, just below the head, as we find it to be in nearly all birds.

I have given this new and extinct form of Shearwater the specific name of *parvus* for the reason that it is probable that, when the species was in existence, it had few, if any, members in the same genus that were smaller than it. The name *Puffinus* was an attempt on the part of the early writers upon ornithology to latinize the word *puffin*. Very early in ornithological history and literature *Fratercula arctica* and its near allies were called *puffins*, for the reason that, when they squatted down upon the rocks where they lived, they appeared to be *puffy* or puffed up—hence “Puffin.” Shearwaters at that time were also called “puffins,” as they were frequently observed in the same localities. However, the vernacular term was soon dropped in their case, while the early writers, in looking up the scientific name for them, hit upon *Puffinus* as a justifiable way in which to perpetuate the name *puffin*, without being really guilty of confusing them with the true birds bearing that appellation (*Puffinina*).

Æstrelata vociferans,¹² sp. nov.

(Extinct.)

[“Cahow”; Bermudan Cahow; Noisy Petrel.]

As set forth on previous pages of the present memoir, the material upon which this new species is based is remarkably abundant, for which science can thank the painstaking labors of Mr. Edward McGall, who collected it in the Bermuda caves.

It has long been a question among ornithologists as to whether the famous “Cahow” was a Shearwater (“*Puffinus obscurus*”?) or a Petrel (*Æstrelata*). In so far as my observation carries me, there is at least one character in the skeleton by means of which we can, with certainty, distinguish from each other these two different kinds of birds. This character is seen in the form of the *cnemial process of the tibiotarsus*. In the genus *Puffinus*—and possibly in some of its near allies—the cnemial process of the tibiotarsus is conspicuously elongate, as we see it in the Grebes and Loons; while in the Petrels it is notably shorter, with rounded superior margin. These differences are well shown in the bones figured on Plate XXVII (figs. 116–125, inclusive). Judging from this character, too, such forms as *Pelecanoides urinatrix* and *Procellaria cooki* are more closely related to the Petrels than to the Shearwaters of the genus *Puffinus* (see Plate XIX, fig. 20, and Plate XX, fig. 24). Judging from this character alone, there is no question but that the “Cahow” of the Bermuda Islands was an *Æstrelata* and not a *Puffinus*. This fact is sustained by other osteological as well as external characters found in the representatives of the two genera in question. For example, both the horny sheaths to the mandible, as well as those parts in the dried skulls when deprived of the sheaths, are positively diagnostic

¹² *Æstrelata*, the generic name for these petrels, is here retained, as it is so spelled in the A. O. U. Check-list. Nevertheless, it is incorrect, and perpetuates a blunder in orthography, for which Charles Lucien Bonaparte is responsible. More correctly, the word should be spelled *Æstrelata*. Prince Bonaparte would be highly complimented were it possible for him to know that an ornithological committee of high standing, in the twentieth century, stood, in cold blood, for what was probably a *lapsus calami* of his.

Vociferans (sp. name), Latin: the participle *vociferans* from *vocifero* (*vox*, gen. *vocis*, voice + *fero*, I bear); hence, noisy, vociferous; here bestowed upon this bird as it was known in life to be a very noisy species.

with respect to these two groups of tubinarine birds. The differences in the external forms of the beaks are well shown in figs. 128-130 of Plate XXXI of the present contribution, fig. 128 giving the beak of a typical Shearwater, and figs. 129 and 130 those of Petrels of the genus *Æstreclata*. I am of the opinion that *Æ. vociferans* was closely related to *Æ. caribbæa* (fig. 129), as I have attempted to show upon a previous page of this memoir.

The differences in the osseous mandibles of a Petrel (*Æstreclata vociferans*) and a Shearwater (*Puffinus lherminieri*) are easily appreciated upon comparing those parts in figs. 5 and 6 of Plate XVI. All Petrels and petrel-like birds possess osseous beaks or mandibles, such as we find figured in figs. 1-5, Plate XVI; in fig. 11 of Plate XVIII, as well as in Cook's and the Diving Petrels.

The *tarsometatarsus* is generally long and slender in the petrel forms; shorter and stouter in the Shearwaters. (See the various figures of this bone on the plates.)

The "Cahow," then, was a Petrel of the genus *Æstreclata*; and with this point settled, I can proceed to give an account of its skeleton.

OSTEOLOGY OF *Æstreclata vociferans*.

The Skull (figs. 1-5, Pl. XVI).—This now extinct Petrel was, in life, morphologically typical of the procellariidine genus to which it belongs, for the subfossil bones at hand in such abundance are ample proof that it was osteologically so; consequently, the remainder of its anatomy must have been in keeping with the characters so clearly in evidence in its skeleton. The *skull* as a whole, apart from its smaller size, essentially agrees in all particulars with the skull of *Æ. lessoni*, as figured by Forbes in his Challenger Report on Petrels, cited on a former page of the present work. The *hyoid arches* are here missing; but it is more than safe to predict that they, too, agreed with those elements as found in other species of this genus.

Viewed from above, we are first to note, in this skull of *Æstreclata vociferans*, the twin elevations of the *parietals*, with a well-marked median and rounded groove between them. In some skulls this latter is carried forward faintly to the "cranio-facial hinge." Generally it is deepest at a midpoint between the orbits, where the superficies between the *supraorbital glandular depressions* most nearly approach

each other. These latter have an average width of 4 mm. and are most conspicuously excavated. Either one extends from the lacrymal of its own side to the prominent postorbital process behind. These glandular depressions are a striking feature of the dorsal aspect of the skull in all the Petrels known to me, as well as in the Shearwaters and other sea-fowl.

The frontal region of the skull under consideration is broad and extensive; mesially, in the depression over the naso-premaxillary part, is to be noted the persistent remains of the frontal processes of the premaxillary. This is present in all eight of the skulls of *Æstrelata vociferans* before me. This character is seen in most, if not in all, Shearwaters of the genus *Puffinus*, and faintly so in *Daption*.

Between the external narial apertures the culmen is very narrow at its middle, but slightly expanded anteriorly and posteriorly. Either *narial aperture* is elongate, narrow, and elliptical in outline. This form of opening, then, is as much rounded behind as it is in front; so that the term "schizorhinal" is hardly applicable to a skull thus characterized.

Beyond the narial apertures the superior mandible is elegantly arched upwards, being bounded on either side posteriorly by the grooves continued forwards from the narial openings, and extended downwards at the apical extremity into a sharp-pointed tip. (Fig. 5, Pl. XVI.)

Passing to a direct *posterior view* of this skull, we are to note the curious form of the *postfrontal processes*, each standing out from the side of the skull in such a way as to resemble a small ear, marked on its hinder surface by the extension forwards of the crotaphyte fossa of the same side. These *crotaphyte fossæ* are most conspicuously excavated, though they do not meet over the unusually large "supraoccipital prominence" posteriorly. Their margins are sharp and to a slight extent elevated, especially the inferior ones. Supraoccipital foramina are not present in this skull; neither do we find those openings in the skulls of the *Puffininae* nor in the Fulmars. Indeed, the rear view of the skull of this extinct Petrel here being considered closely resembles the same aspect of the skull in most species of *Fulmarus*.¹³

¹³ Shufeldt, R. W., "Contributions to the Comparative Osteology of Arctic and Sub-arctic Water-Birds." Part I, *Journ. of Anat. and Phys.*, Lond.,

Turning to the lateral aspect of the skull in hand, it will be observed from fig. 5 of Plate XVI that the "interorbital septum" exhibits large vacuities in it, both centrally and above; though in most skulls of this species the *foramen rotundum* is entire—that is, surrounded by bone.

While protected posteriorly by the flaring *os squamosum*, the entrance to the ear is much exposed in front, affording the opportunity to fully examine its interior structure and the articular facet for the *os quadratum*. Anteriorly, the large quadrilateral *pars plana* is thoroughly coössified for its entire outer boundary and above with the big *lacrymal bone*, and the latter likewise, superiorly and anteriorly, with the frontal and nasal of the same side. Here is a point that at once distinguishes the skull of this extinct Petrel from the skull of a Shearwater of the genus *Puffinus*; for in the latter group we always find the *lacrymal bone* to be a free element which promptly comes away during the process of maceration. In *Æstrelata* it is deeply grooved antero-posteriorly at its middle, and in this groove we always find a large, circular, pneumatic foramen, the bone extending outwards and backwards just below it. *Daption capense* has a *lacrymal* and a *pars plana* essentially agreeing with what I have just described for the subject in hand.

Between the *lacrymal* and the posterior sharp edge of the *nasal* of the same side no bony wall exists; so that, when viewed upon this direct lateral aspect, one can look *through* the skull over the broad vomer below, as is well shown in fig. 5 of Plate XVI; in other words, the midposterior part of the rhinal chamber is entirely lacking in osseous, protecting, lateral walls.

At the side of the *superior ossaceous mandible* beyond this the surface is extensive and smooth, with its lower tomial edge cultrate to the apex beyond.

A *quadrate bone* has a broad orbital process, with a markedly truncate extremity; and at the base of this, internally, we always find a single, circular, pneumatic foramen of some considerable size. Above the articular head has two very independent articular facets, each of an ellipsoidal form—the outer being the larger of the two.

Oct., 1888, XXIII, n. s., Vol. III, Pl. II, fig. 8. Other skulls or marine bird-forms are figured in this part of the work in question, which can be compared with the skull of our Petrel with advantage.

The articulatory surface for the mandible is irregular in contour and extensive. The body of the bone, including the orbital process, is greatly compressed transversely.

I find no pterygoids in either of the collections at hand, but it is not difficult to conceive what they were like.

The *quadrato-jugal* or *infraorbital bar* is extremely slender, and continues to be so until it joins the triangular, horizontally disposed *maxillary* anteriorly. Its inturned articular nib for the quadrate, at its free, posterior end, is very small.

Posteriorly, the *basis cranii* is bounded by the semi-circular line of the occipital crest, here forming the lower boundary of the crotaphyte fossæ.

In some of these skulls the *foramen magnum* is almost circular in outline, while in others it is distinctly cordate, the *occipital condyle* being unusually small for a bird having the size that *Æstrelata vociferans* had, while its center, posteriorly, may or may not exhibit a faint notch.

The small foramen above and on either side of the foramen magnum has a deep though narrow groove running forwards from it, to be lost on the basitemporal, between the occipital condyle and the wing of the *os squamosum*. This pair of groovelets are very distinctive of the skull in Petrels and Shearwaters, and less in some other tubinarine birds.

The *basitemporal* region is smooth, nearly level, and triangular in outline; while beyond its anterior apex are to be observed the pair of small, sessile facets, one on either side, for the pterygoids. Between these and the posterior, articular extremities of the palatines is to be seen the inferior rounded surface of the sphenoidal rostrum, which is exposed for a distance of several millimeters (fig. 4, Pl. XVI).

The large *vomer*, with its decurved, pointed, anterior extremity, fuses with a palatine upon either side, although these latter bones do not ankylose together for their hinder moieties. Either bone, for its latter or posterior half, has its internal and external margin raised, while the dorsal aspect is developed as a scroll-like elevation. Beyond, the *prepalatine* is much flattened in the horizontal plane, well separated from the fellow of the opposite side, while most distally it

turns outwards to fuse with the inner side of the superior mandible (fig. 4).

The short, scroll-like *maxillo-palatines* do not meet in the middle line, nor do they come in contact with the anterior free extremity of the vomer. Such part of the roof of the mouth as lies beyond the palatines and between the sides of the *premaxillary* is not spanned by bone, thus allowing an uninterrupted view of the interior of the fore part of the rhinal chamber.

As one would naturally suppose, the *medio-stapedial element* of the middle ear, and the *sclerotal plates* of the eye, are, for very obvious reasons, not to be found among the bones of these two collections.

The *mandible* has the typical V-shape pattern, with the sides of the anterior dentary portion low and thickish. The symphysis is very short, while the apex of the enlarged distal extremity is acute and decurved. It is longitudinally grooved dorsally. For the posterior ramal portion, we find the side thin and lofty, with the superior margin sharp and the lower one rounded. No "splenial vacuity" is present in fully adult birds, while posteriorly, on the mesial aspect, there is considerable excavation or concavity just anterior to the enlarged articular posterior extremity. This latter is concaved and truncate on its posterior aspect; double-concaved dorsad, to accommodate its surface to the quadratal articulation, and its inturned part, on this upper side, showing the minute, pneumatic foramen usually found in that situation.

The Vertebral Column.—When Forbes came to study the Petrels collected by the naturalists of the Challenger Expedition, as cited on a previous page, he found, in a specimen of "*Æstrelata grisea*" that there were fifteen (15) *cervical vertebrae*, seven (7) dorsals, eleven (11) sacrals, and seven (7) caudals, making forty (40) in all. As he does not mention the *pygostyle*, I presume he simply considered it as the ultimate or terminal caudal.¹⁴ He also found that in "*Æstrelata grisea*" there were eight (8) pairs of vertebral ribs—that is, one cervical pair and seven (7) dorsal, or ribs joining with the costal ribs below. The dorsal ribs supported *epipleural appendages*, with

¹⁴ He also examined another Petrel, which I am inclined to believe was not an *Æstrelata grisea* (*b*), and he seemed to doubt the correctness of the identification. It had forty-one (41) vertebrae in its spinal column (*loc. cit.*, p. 419).

perhaps the exception of the last pair, and there was probably a pair of free *cervical ribs*.

The vertebræ and ribs in the collection of the American Museum of Natural History do not fully admit of completing the chain, in order to assemble a perfect skeleton of *Æstreclata vociferans*, while they do in the collection of Mr. McGall. After very careful study, I have selected from the latter lot a string of vertebræ that I must believe are very nearly, if not quite, correct. They may, of course, have belonged to a number of different individuals, and are probably of both sexes at different ages; but this is the very best one can do with such a mixed lot of material. In my own mind there is no question but that the *number of vertebræ* in the spinal column of the extinct Petrel here considered agreed with "*Æstreclata grisca*," as enumerated above; so, too, for the *ribs*. One thing is certain: both species possess *eleven* vertebræ in the sacrum. Then I selected the *cervico-dorsal* series *before* I turned to the work of Forbes on *Æstreclata grisca*, and very much to my satisfaction I found that I had settled upon the same number of *cervicals* and *dorsals* that he had entered in his table—that is, 15 *cervicals* and 7 *dorsal vertebræ*. The arrangement is precisely the same throughout—ribs, epipleural appendages, and all—in *Ossifraga gigantea* as it is in the true petrels, but not in any of the rest of the *Procellariidæ*, in so far as Forbes and I have examined them.

The *atlas* is very delicately fashioned, its body being incomplete above, the remaining parts either thin or small, and the bone is unmarked by any passage on either side for the vertebral arteries. This is also the case with the *axis*, in which vertebra the odontoid process is short and feebly developed. It has, however, a well-pronounced hæmal and neural apophysis, and its diapophyses are turned abruptly upwards.

We find that the *third cervical vertebra* also possesses strong neural and hæmal spines, while perfect canals for the vertebral arteries are present in it, and short pleurapophyses project backwards from beneath them, one upon either side. These are longer and more spiculi-form in the *fourth cervical*, and in this the pre- and postzygapophyses are an evident feature. Its neural and hæmal spines are on the road toward aborting. From this point on, to include the 15th vertebra which supports a pair of free ribs, the vertebræ of this division of

the column become gradually broader and broader; the neural spines disappear completely; the very short pleurapophyses are extremely delicate, while the passages for arteries, both ventrally and laterally, are much as we find them in the Petrels generally.

All seven of the *dorsal vertebræ* support oblong neural spines, while the hæmal ones, although present in every case, are best developed in the middle of the series. There is an absence of all ossification of any of the tendons of the muscles of the back, so often seen in other groups of birds; while the metapophyses of the broad and well-developed transverse processes are fairly in evidence. †

The *neural canal* varies but little in capacity throughout the vertebræ of the cervical and dorsal regions of the spine; and upon the whole, all the parts of these bones are reduced to the simplest form known to occur in the vertebræ of birds.

All the *ribs* are very thin and slender, with the "epipleural appendages" in the mid-series very long. These last are all coössified with their respective ribs in the dorsal ribs, while they are entirely absent in the case of the cervical and pelvic ones. *Costal ribs* are also delicately fashioned, and the last pair of them, in either instance, do not reach the costal border of the sternum, but run, in both cases, into the rib next beyond, to fuse with it at a point some little distance above its sternal articulation.

Coming to the *pelvis*, I find it to possess characters corresponding with those as they occur in the pelves of typical petrels generally. That portion of it recognized as the "sacrum," made up, as it is, of *eleven* vertebræ, is not large at its extremities, while it presents an unusual swell for its middle third. Here the various outstanding processes are very short and inconspicuous, although the leading two of them abut against the nether surface of the ilium upon either side. This also applies to the three "presacral" vertebræ, wherein the diapophyses are short and connected by bone at their outer extremities. The last five sacrals possess much longer diapophyses, and they, too, have their outer terminations fused together by an osseous connecting band, which may or may not be extended to the ultimate vertebra. Upon the outer edge of this band, on either side, the surface is molded to receive in articulation the ilium of that side, as are the transverse processes of all the vertebræ beyond.

The *ossa innominata* do not coösisify with the sacrum, and may be

easily detached from it. Along the sides of the latter we are to note that, in the case of the leading seven (7) vertebræ, the exit for the *sacral nerves* consists, in any case, of small, twin foramina, one being placed immediately above the other. We also find this in the Shearwaters and many other birds, both land and water species. The crest of the sacrum of the bone here being considered is well developed and extends from the leading vertebra, backwards, to the middle of the bone, where it is lost upon the general surface. Its superior margin is thickened by the edge being capped by an osseous dilation of nearly a millimeter in width. This projects well beyond the crest anteriorly, overhanging the prezygapophyses of the first sacral vertebra. (Compare the figures of sacra upon Plates XXVI and XXVII.)

Passing to the *ilium* of an "os innominatum," I find the preacetabular part to have an average length of about 2 cms. Its edges are sharp and round; the smooth surfaces of its dorsal and ventral aspects being concave in the first and correspondingly convex in the latter instance. Dorsad, the preacetabular part of the ilium is of limited extent, and the aforesaid concave and convex surfaces are reversed. The rounded *antitrochanter* faces directly downwards and forwards, occupying its usual site. Hardly any osseous base is to be found in the circular cotyloid cavity, and it is divided from the large elliptical ischiadic foramen by a very narrow isthmus of bone. There is no evidence of any *prepubic* process, while the rather small obturator foramen is almost entirely merged into the "obturator space," which is here very extensive. On its lateral aspect, the *ischium* is quite flat and entirely smooth. Posteriorly it is produced backwards and downwards as a delicate and curved process of considerable length, which finally terminates in a little foot-like expansion that articulates by its entire lower edge with the superior margin of the narrow, slender, and elongate *postpubis* at just a short distance anterior to its free posterior extremity (fig. 63, Pl. XXVI). There is no true "ilioischiadic notch" present in this pelvis, as seen in many other birds, for example, in *Puffinus borealis* and other Shearwaters. This "notch" is also to be seen in some of the Fulmars, as *Fulmaris glacialis*, but it is more open than it is in the Shearwaters. (Compare figs. 17, 21, and 25.)

But four or five *caudal vertebræ* were discovered of *Æstrclata vociferans*, and they appear to be from the middle of the series of

those bones of the skeleton of the tail. No *pygostyle* at all occurs among the material, which is somewhat remarkable, for an unusual number of cervical and dorsal vertebræ were found, and the terminal piece of the tail is comparatively large in all petrels. The caudal vertebræ are of simple form in mid-series, with short, rather stout diapophyses that are bent downwards. Neural spines are also present in the majority of them, while apparently the last segment or two possessed a bifurcated hæmal spine. It would appear as though the neural canal extended posteriorly as far as the pygostyle, for it is present in all these caudals in the collection.

In all probability *Æ. vociferans* possessed seven (7) caudal vertebræ and a pygostyle. The tubinarine form possessing the greatest number of these caudal vertebræ is *Pelecanoides urinatrix*, which has nine (9) and a terminal piece. Forbes, in his above-cited table, gives *nine*, but does not count the pygostyle (fig. 21, Pl. XX). This is a mistake, I think, unless it be generally understood that the aforesaid terminal bone is, in a way, to be reckoned as an ossification apart from the vertebral chain as a whole.

The Sternum and Shoulder Girdle.—As will be noted from the lists given above, there are nearly a dozen sterna of the petrel here being examined in the collections at hand, and plenty of scapulæ, coracoids, and os furculæ to study and compare, with the view of noting the characters of that part of the skeleton. (See figures of these several bones on Pls. XXII, XXIII, XXIV, and XXV.)

The *sternum* varies to some extent in some individuals, but probably not for sex. In some the outline of the body is nearly square, while in others it is more, or slightly more, parallelogrammatic. There is also a variance in the widths and lengths of the xiphoidal processes, they being short and narrow in some sterna, and rather wider and longer in others. The bone appears to always be non-pneumatic, and when viewed from above the body presents a great concavity with respect to form. The triangular and pointed costal processes flare out, one upon either side, and there are, as a rule, six narrow facets upon either costal border for articulation with the costal ribs or hæmapophyses. Its anterior border is thickened so as to afford surfaces for articulation with the coracoids; they meet each other anteriorly at an angle of nearly 90 degrees, there being a well-pronounced transverse notch at the apex of the angle in the mid-

longitudinal line. This is separated from the small, flattened "manubrium" beyond it by the rather capacious coracoidal grooves, which latter are continuous at the median point, and carried around laterally, on either side, to the middle of the base of the coracoid process.

Carina has a thickened anterior border, which is longitudinally grooved down its anterior face, below which the "carinal angle" projects with great prominence (fig. 32). This keel, too, is carried the entire length of the sternum to the ultimate point in the middle line of the mid-xiphoidal process. On the whole it is deep and of triangular outline, with slightly thickened free margin below. The convex ventral surface is smooth, all to the usual raised lines found there indicating the divisional areas for the pectoral muscles.

Distally, the xiphoidal margin is twice-notched upon either side, the "notches" being profound and broad, giving rise to a mid-xiphoidal process, with a lateral one and an intermediary one upon either side.

This sternum has an average width of 2.8 cms. by a length of 4.3 cms., the former being taken on a transverse line adjoining the middle points of the costal borders, and the latter from the middle point of the anterior border to the posterior extremity of the keel. It will be observed that this sternum is quite a different appearing bone from that of a typical Shearwater, for example, such a form as we see in figs. 126 and 127 of Plates XXIX and XXX.¹⁵

On the plates already cited above I give a number of figures of the *furculum*, coracoids, and scapulæ of this extinct bird. The former is seen to be of the usual U-form of bone found in Petrels generally. The clavicular limbs are much bowed to the front, while the hypoleididium may be said to be aborted below. Above its usual site, anteriorly, an excavation appears, while behind it, on the posterior median

¹⁵ Since describing above the skeleton there shown, I have received the following letter in regard to it, dated December 4, 1915, at the Museum of Comparative Zoölogy, Cambridge, Mass., and addressed to myself:

"Dear Sir: I duly received the Shearwater skeleton loaned you for study. It came without any injury whatsoever. I asked our Mr. Bangs to compare the skeleton with skins in the collection, and he identifies the skeleton as *Puffinus assimilis* without doubt, and probably the subspecies *gavia*.

Yours truly,

SAMUEL HENSHAW,
Director."

surface, a vertical line is raised where the clavicles are joined below. The free extremities above are drawn out to some extent and pointed. Each has on its external face an antero-posterior elongated facet for articulation with the corresponding coracoid. The apices of the free extremities are 2 cms. apart; and from either apex of a free end to the median lowermost point of the arch equals 3.4 centimeters, more or less.

For its entire length a *scapula* is very much compressed vertically, and about a centimeter or less of its free posterior extremity is markedly dilated. It is uniformly curved in the vertical plane, from one end to the other, while its outer border is gently concave throughout its length, its inner one presenting a similar convexity—either border being rounded off rather than sharp. Distally, the bone is blunt-pointed, while the vertically flattened head, supporting the usual articular facets, presents anteriorly a slightly thickened transverse edge of margin for articulation with the coracoid of the same side. The extreme length of a scapula averages about four centimeters, with a width of three millimeters.¹⁶

The Pectoral Limb (Plates XXIV–XXVI).—There is an unusually large number of the bones of this extremity in the combined collections before me at this writing—that is, when we come to consider the fact that they represent an extinct species, and the additional fact that our National Museum has not a single skeleton of any Petrel of the genus *Æstrelata*—extinct or existing—in its entire collection of skeletons. Here there are, to represent *Æ. vociferans* alone, nearly 50 humeri, with all the other long bones of the arm in proportion.

It is very interesting to find that the *humerus* of *Æ. vociferans* agrees *very* closely, in all of its characters, with the humerus in any average Shearwater of the genus *Puffinus*; at the same time it departs, in many respects, from the humerus of any of the smaller Petrels of the genus *Oceanodroma* with which I have compared it, and perhaps from the humeri of the allied genera *Bulweria*, *Halocyptesia*, and *Thalassidroma*, which have not been seen by me. These differences

¹⁶ In examining these scapulæ for the last time, I came across the anterior half of one that evidently belonged to a much smaller bird than *Æstrelata vociferans*; there is a great probability that it may have belonged to a specimen of *Puffinus parvus*, a distinct species described above. It is to be found in the collection belonging to the American Museum of Natural History.

are very marked, but it will hardly be necessary to enter upon the description of them here. I may say, however, that they are principally to be seen in the proximal extremities of the bones in question. As a matter of fact, the small Petrels just named are, with respect to their osteology, very different birds as compared with the representatives of either of the genera *Æstreclata* or *Puffinus*.

In our present subject the humerus has an average length (both sexes considered together) of 8.15 cms., its smooth shaft being but very slightly curved; the convexity is on the anconal side and uniform from head to distal end.

The radial crest is distinctly triangular in outline, the superior angle terminating in a distinct nib, the whole being bent palmar.¹⁷

The ulnar protuberance or "inferior crest" is very conspicuously developed, and, on the whole, bent toward the anconal side. It harbors, as usual, the pneumatic fossa, which is here deep and circumscribed. At its base may be discovered a few minute pneumatic foramina, for nearly the entire skeleton of this Petrel is very largely permeated by air, the usual "air-holes" being found at their usual sites.

The "incisure capitis" is well marked, while the articular part of the head of the bone is not especially extensive. Points about it for muscular insertion are defined by distinct, localized areas, marked with varying definition in different bones, or rather in those that belonged to different individuals.

Distally, we see the large epicondylar or ectepicondylar process standing out conspicuously from the side of the shaft, roughened, as it is, for tendinal insertion. More centrally, and just above the trochleæ, is a deep, circumscribed concavity for the insertion of the inferior brachial muscle. The entepicondylar process is particularly prominent; and, indeed, this end of the humerus in the skeleton of the bird under consideration has each and all of its characters unusually pronounced, though not any more so than they are found to be in any of our Shearwaters of the genus *Puffinus*.

According to the variations due to age and sex, the length of the *ulna* may run all the way from 8.6 cms., more or less, to 9.4 cms., more or less, and is seen to be a strong and nearly straight bone, being

¹⁷ This crest, the "crista superior" of some authors, is low and rounded in *Oceanodroma*.

but very slightly bowed anconad-wise; its shaft is smooth, and for the most part trihedral upon section. Papillæ for the quill-butts of the secondary feathers of the wing are but faintly in evidence, the first five or six proximal ones being best marked. At the extremities the usual articular facets for the humerus, radius, and ulnare are present, and to all appearances the bone is a pneumatic one.

A *radius* is a very slender and very straight bone; it has an average length of 8.55 cms., and presents the usual ornithic characters found in the Petrels generally at either of its extremities.

No specimens of the two bones of the carpus—the *radiale* and *ulnare*—are found in any of these collections; but it is fair to presume that they agreed in all essential particulars with the corresponding elements in the wrists of typical Petrels generally.

As in the case of the long bones of the brachium and antibrachium, the main bone of manus—the *carpometacarpus*—is found to vary in length, and for similar reasons. Upon measuring a series of them, they seem to stand between 4.2 and 4.35 centimeters in this respect (Pl. XXVI, figs. 65, 66). The main shaft is straight and subcylindrical in form, being longitudinally grooved down its palmar aspect for tendinal passage, which groove is best marked distally. Shaft of medius metacarpal is almost parallel to the last described, but only about one-fifth its caliber. It is transversely compressed for its entire length, and gradually enlarges as it coössifies with the distal extremity of index metacarpal. This bone likewise has all the appearance of being a pneumatic one; but I have failed to discover, with absolute certainty, the foramina to substantiate it. They are probably very minute and at the proximal extremity.

On Plate XXVI (figs. 71, 72) I give two views of the proximal phalanx of index digit, which shows its narrow expanded portion, ending distally in a distinct, outstanding little process, with another nearly as prominent at the opposite side of the distal articulation. This expanded part has a very thin, sharp edge or margin posteriorly, while the anterior surface of its shaft is flat.

Several terminal digital phalanges occur in these collections, and I have also figured them on Plate XXVI (figs. 75, 80-82). They present, with their trihedral shafts, pointed distal extremities, and proximal articular ends, nothing worthy of detailed description; though, doubtless, were one to compare a sufficient series of these bones with

a corresponding series chosen from Shearwaters and other tubinarine birds, one could tabulate the exact difference to be found among them. They would be unimportant in value, however, as compared with bones of other parts of the skeleton presenting more distinctive characters, for example, such as we find in the skull, the sternum, and some of the long bones of the limbs. These remarks apply equally well to the numerous phalangeal joints of the pes.

The Pelvic Limb (Plate XXVIII).—For the most part, the bones of this extremity seem to enjoy more or less pneumaticity, especially the shafts of those of the thigh and leg. We are struck with the small size and *shortness* of the *femur* as compared with the humerus of the pelvic limb. It averages but little over three centimeters in length, its subcylindrical shaft being but slightly bent between its extremities, the convexity being in front, and best marked at about the juncture of middle and lower thirds.

The "trochanter major" is but feebly developed, and the summit of the bone is flat and articular, the small *caput femoris* being profoundly pitted for the insertion of the ligamentum teres. Distally, the condyles are also small, and present all the usual characters as we find them in the femora of Petrels generally. In Shearwaters the shaft of the femur generally is far more bent or arched than it is in *Æstrelata* and its immediate congeners. In *Occanodroma* the shaft of this bone is very straight.

No *patellæ* occur in any of these collections, and so small as sesamoid was probably overlooked in collecting.

Passing to the bones of the leg, I find that the *tibiotarsus* varies in length as in the case of the other long bones of the limbs. It averages between 6. and 6.3 centimeters in length (Pl. XXVIII, figs. 122, 123). It has a very straight shaft, which, for its middle third, is subcylindrical in form, and somewhat compressed antero-posteriorly below.

Proximally, the bone is characterized by a very conspicuous enmial process, to which I have referred on a former page of this work. This process is flat and triangular posteriorly; its ectoenmial part is considerably reduced, while the entoenmial portion is expanded and extends directly to the front. The common superior border to these two processes is somewhat thickened and of a sub-hemicircular outline. As already shown above, this is the general character of the

cnemial process in the true Petrels, while in the Shearwaters (*Puffinus*) its summit is more generously and characteristically extended, constituting a certain *facies* that is unmistakable.

At the distal end of this tibiotarsus of *Æstrelata vociferans* we note the deep, longitudinal groove for tendons anteriorly, spanned below by the minute osseous bridge to confine them within it. The condyles are prominent here owing to the deep intercondylar valley between them. Posteriorly they are sharp-edged, and the space between them is much shallower. Externally, we note the thin, fibular ridge for articulation with the *fibula*, which latter is but a feebly developed bone, lightly attached to its larger companion by a scanty ligamentous attachment. The lower free end of the articulated fibula reaches down to about the junction of middle and lower thirds of tibia's shaft,¹⁸ and it is here reduced to almost hair-like dimensions.

Petrels, as a rule, have a slenderer *tarsometatarsus* for its length than have the Shearwaters and some other *Tubinares* (compare figs. 106-110, Pl. XXVIII; also figs. 20 and 24); while at the same time its characters are pretty much the same. In a series of the bones its length runs 3.4 cms., 3.5 cms., and so on, which is about the average for them. At the summit we find the twin articular concavities for the femur well marked, and a well-developed intercondylar eminence between them on the anterior border. The *hypotarsus* is rather short except upon the inner side, where it is continued down its upper third of the shaft as a thin, lateral plate of bone. For the rest it is composed of three processes, 3.7 mm. deep, dividing it into two deep grooves for the passage of the usual tendons of the muscles of the leg.

The shaft is straight and strongly grooved, both anteriorly and posteriorly, for its entire length, longitudinally. Passing to the *distal trochlea*, it is to be noted that the central one is considerably bigger than either of the others, while it is also placed lower down and more to the front. The inner one is the highest up and situated the farthest to the rear, while the outer one holds an intermediary position. Between these three trochleæ, grooves are carried up a short distance

¹⁸ As slender as the attachment of the fibula to the tibiotarsus is, I find one specimen in which the two bones did not part company, notwithstanding the long time which must have elapsed since the death of the bird to which they belonged; the circumstances under which the specimen was collected and the transportation and handling since.

upon the anterior aspect of the shaft, especially between the middle and outer ones, wherein we find, as usual, and at its usual site, the elliptical foramen for the passage of the anterior tibial artery to the plantar aspect of the foot.

There is rather a large number of *pedal phalanges* in the collection, especially in Mr. McGall's part of it. These I have assorted according to their *lengths*, but without a skeleton of the foot of this Petrel before me, or of an *Æstrelata* of any species. In face of the fact that these joints vary in size according to age and sex, and, further, that there are nearly thirty of them in the two feet of a single individual, I would hardly undertake to restore a foot—either the left or the right—from the material at hand. Were *all* the phalanges represented, and for *both* feet, this could be done with certainty, however large a number there was in the collection. An X-ray or radiograph of a foot of one of the specimens of *Æstrelata caribbæa*, of the U. S. National Museum collection, might be of assistance in the matter, but the gain would hardly justify the outlay in time and expense. In any event, the skeleton of *pes* in *Æstrelata vociferans* was doubtless quite in agreement with what we would find in any medium-sized Petrel now in existence, and our knowledge of that is already in the possession of science.¹⁹

ADDENDA.

After the above memoir was entirely ready for publication, with its sixteen plates, Mr. McGall made additional collections of bird-bones at the Bermuda caves, visiting others not previously examined

¹⁹ Among the *pedal phalanges* of Mr. McGall's collection, I have met with a single joint which I am inclined to believe belonged to the species of Shearwater now bearing his name and described above. It is very straight and markedly slender; further, it is altogether too long to have belonged to *Æstrelata vociferans*, as it measures no less than 2.9 cms. in length. In the skeleton of the foot of a specimen of *Puffinus borealis* (No. 17769, Coll. U. S. Nat. Mus.), the *basal phalanx* of the *inner toe* measures in length 3 cms., and the bone is slenderer than the basal joint of the middle toe, which latter measures in length 2.8 cms. At the same time it is, as I say, a somewhat stouter bone than the aforesaid basal phalanx of the inner toe. Judging from this data, I believe that the subfossil pedal phalanx just referred to above belonged to an adult specimen of *Puffinus mcgalli*, and possibly to the same individual to which belonged the sternum described upon a previous page of this memoir.

by him. In these extremely dangerous operations he was associated with Mr. Anthony Tall, though the former explorer was the one who undertook the more hazardous descents necessary to reach the cave entrances, which, in any instance, invariably faced seawards; so that a person, in order to gain entrance, had to be lowered down by a rope and receive other assistance at the hands of his friends above.

The material thus collected was sent to the American Museum of Natural History, and some of it was distributed among other American and British museums. Originally it was the intention to have the American Museum publish this memoir with its addenda when completed by me; but, after holding it for many months, so much previously accepted matter preceded it for publication that Mr. McGall and his associates decided to allow me to place it where it would sooner see the light and the results be given to science. This was not fully decided upon until both of the explorers had visited me at my home in Washington, D. C., and fully discussed the subject, later giving me instructions in writing in regard to my choice of place for publication.

After this had all been duly arranged, Doctor Lucas kindly turned over to me the added collection of bones that was in his keeping, and it was found to consist of the following lots. This all occurred during the summer of 1917. In the spring of that year, when this country declared war against Germany, Mr. McGall was commissioned first lieutenant in the United States Coast Artillery, and at this writing (Dec. 30, 1917) he is probably with our troops in France.

This extensive material has all been carefully compared with the bones described in the main memoir, and the results, in the way of numbers of specimens and their identification, are set forth in the following:

TABLE.

- 17 crania of *Æstrelata vociferans*. More or less imperfect; show but little individual variation. On the frontal region (superiorly) the transverse diameter between inner edges of supra-orbital glandular depressions varies in length from one to three millimeters. Some little variation in size.
- 1 perfect mandible of *Æ. vociferans* and 8 pieces of others.
- 9 ossa quadrata of *Æ. vociferans*.

I pterygoid.

- 150 vertebræ (not assorted and not referred); probably belonged largely to *Æ. vociferans*.
- 200 ribs (approx.). (Not assorted or referred.)
- 32 sterna (adults), more or less imperfect, of *Æ. vociferans*.
- 49½ coracoids of *Æ. vociferans*. (Thirty lefts, nineteen and a half rights.) Adults more or less perfect.
- 36 scapulæ; 23 rights, 13 lefts. Mostly perfect.
- 22 perfect furculæ of *Æ. vociferans*.
- 9 fragments of furculæ of *Æ. vociferans*.
- 31 ossa innominata, right side; majority perfect. *Æ. vociferans*.
- 24 ossa innominata, left side. *Æ. vociferans*.
- 39 sacrum of *Æ. vociferans*; large number nearly perfect.
- 36 humeri (right side) of *Æ. vociferans*. Nearly all perfect, and adult, with but one or two exceptions.
- 49 humeri (left side) of *Æ. vociferans*. Mostly perfect; three are but halves; three subadult.
- 41½ left ulnæ of *Æ. vociferans*. All more or less perfect. Adult.
- 51 right ulnæ of *Æ. vociferans*. All more or less perfect. Adult.
- 90 radii of *Æ. vociferans*. Nearly all perfect. Rights and lefts mixed. No carpal bones found.
- 21 carpometacarpi; adults; nearly all perfect. *Æ. vociferans*; rights.
- 26 ditto; left side. Proximal joints of index digit; *Æ. vociferans*. 13 of right side, or right pectoral limb; 11 of left side, or left pectoral limb.
- 29 non-assorted finger-joints. Apparently most all of them belonged to *Æ. vociferans*. Adults.
- 13 femora (rights). *Æ. vociferans*. Quite perfect. Adults.
- 23 femora (lefts). *Æ. vociferans*. Quite perfect. Adults.
- 12 fibulæ; adult. *Æ. vociferans*.
- 41 tibio tarsi (rights). *Æ. vociferans*. Nearly perfect, many quite so. Adults.
- 38 tibio tarsi (lefts). *Æ. vociferans*. Nearly perfect, many quite so. One has a perfect fibula articulated with it.
- 13 tarso-metatarsi (rights). *Æ. vociferans*. Quite perfect. Adult.
- 22 tarso-metatarsi (lefts). *Æ. vociferans*. Quite perfect. Adult.

68 toe-joints (adults), mostly quite perfect; belonging to different species in the collection. Not assorted or referred.

MISCELLANEOUS LOTS.

I was personally informed by Mr. Edward McGall and Mr. Anthony Tall that in other lots of the collections sent to Harvard College, British Museum, etc., were found specimens of an os furcula of a bird of very small size. This report is sustained by the present collection, for in one or two of the miscellaneous lots I find various bones that belonged to some very small species; in fact, as small as any bird in our present American avifauna, barring the humming birds. These bones are as follows:

In one lot:

Left femur (distal condyle gone).

Right tarso-metatarsus, distal moiety (adult) measures 1.5 mm. across the ends of the trochleæ.

Left femur, distal moiety. Transverse diameter of condyles 2 mm.

Shaft of a tibio-tarsus, extremities missing.

In another lot of:

Numerous bones of birds described in the memoir occur also the distal moiety of a femur that belonged to a very small species of bird; also a perfect left femur (same species?), which measures 1.6 cms. in length; a rib; the distal portion of a left tarso-metatarsus, and a nearly perfect left humerus; length 1.5 cms. The bones in this lot were mixed up in a considerable quantity of fine, dry silt from the bottom of the cave. Some minute species of mollusks (2 sp.), with a form like a helix, were also found in this lot.

In still another lot:

Made up of various calcined bones of species described in the memoir (fragmentary), there occurs a nearly perfect right tibio-tarsus of a bird, with a total length of 3.1 cms. Apparently the bone is of a passerine type and belonged to a species about the size of a large sparrow.

After all the bones enumerated above had been carefully selected

and duly counted, there remained quite an extensive collection of bones which, upon comparison with the corresponding ones in the collection as a whole—that is, with all the material that ever came before me from the Bermuda caves, both main lots—proved to be, beyond all doubt, those of *Puffinus parvus*. These bones further agree, in their morphology, lengths, and general proportions, with the *type bones* of this extinct Shearwater, as figured and described in the body of the present memoir. In this lot there are found:

4 skulls (adults), pterygoids and quadrates missing; the basal, frailer parts broken off and lost. (No mandibles accompany them.) Otherwise quite perfect.

(In the large collection of *vertebra* listed above there may be, and probably are, some that belonged to this small Shearwater. This applies to other small bones, as toe-joints, finger-joints, etc.)

5 sternums; more or less perfect.

4 coracoids; 1 right and 3 lefts.

5 scapulæ; 2 rights and 3 lefts.

2 os furculæ (perfect); 4 fragments of others.

13 humeri; 4 rights, 9 lefts.

10 radii (rights and lefts); some quite perfect.

9 ulnæ; three rights and 6 lefts.

6 carpo-metacarpi; 2 rights, 4 lefts.

4 femora; 1 right, 3 lefts.

9 tibio-tarsi; 3 rights, 6 lefts. All quite perfect; in fact, all the limb-bones are in an excellent state of preservation, and the majority of them perfect.

7 tarso-metatarsi; 5 rights, 2 lefts.

Finally, the collection contains the imperfect sternum of a very small species of Shearwater (*Puffinus*), smaller than Audubon's Shearwater. It is more than likely that this bone belonged to an adult specimen of *Puffinus parvus* Shuf. The antero-superior portion is broken off and lost; otherwise the bone is quite perfect.

CONCLUSIONS.

There is but little to be said under this head. The creation of the new species, *Puffinus mcgalli* and *P. parvus*, is amply justified, based,

as it is, on good and sufficient material in either case. With respect to *Æstrelata vociferans*, I am free to confess that when this work was in its early stages I was by no means convinced that a good case was to be made out, especially when all the reports came in to me from so many large museums in America and Europe that there were *no skeletons* of any species of *Æstrelata* in existence; or, if there were, they could not pass out of the keeping of the institutions owning them for the use of a private investigator engaged upon such researches as are here set forth. However, as soon as a serious study of the material was entered upon, it became evident that the subfossil bird-bones of the "Cahow" of Bermuda belonged, without question, to a Petrel and not to a Shearwater, as has heretofore been generally supposed. It then remained but to prove to which species they belonged; and, as the steps leading to this proof are very fully demonstrated, point after point, in the present contribution, it is obviously unnecessary to recapitulate them here.

Note.—The collections made by Mr. Edward McGall and Mr. Anthony Tall, listed on pp. 382 *et seq.*, which were presented by these gentlemen to Dr. R. W. Shufeldt, have been turned over by Dr. Shufeldt to the Carnegie Museum, and have become its permanent property.

W. J. HOLLAND.

EXPLANATION OF PLATES.

(All the figures in the plates are reproductions of photographs made by the author of the specimens described.)

PLATE XVI.

FIG. 1. Superior view of the skull of the "Cahow." McGall Coll., nat. size; adult; imperfect (right zygoma lost, etc.). Some of the matrix still seen adhering to it, between the orbits and in the nostrils. Lower mandible removed. Either *lacrymal* coössified at the side of the skull and the suture obliterated.

FIG. 2. Same view of the skull of another individual of the same species as shown in Fig. 1; nat. size; adult. McGall Coll. Imperfect. Mandible removed.

FIG. 3. Same view of the skull of still another individual of the same species ("Cahow") as shown in Figs. 1 and 2; nat. size; adult. McGall Coll. Imperfect. Mandible removed. The three crania shown in Figs. 1-3 show how little individual variation exists, as a rule, in this part of the skeleton of the "Cahow." The shortest line between the supraorbital glandular depressions is, however, seen to vary to some extent.

FIG. 4. Basal view of the cranium of a "Cahow," nat. size; adult. McGall Coll. Mandible removed, and the pterygoids and quadrates missing. Vomer coössified with palatines.

FIG. 5. Right lateral view of the skull of a "Cahow," with *mandible*—the latter doubtless from a different individual. Nat. size; adult. Coll. Amer. Mus. of Nat. Hist. Quadrates were probably from another specimen, while the pterygoids are missing.

FIG. 6. Right lateral view of the skull and mandible belonging to a skeleton in the collection of the U. S. National Museum labeled "*Puffinus obscurus*" (No. 17724, Bermudas, C. Maller, collector).



fig. 1.



fig. 2.



fig. 3.



fig. 5.



fig. 4.



fig. 6.



PLATE XVII.

FIG. 7. Right lateral view of the skull, including mandible, of a specimen of *Puffinus major*; adult; nat. size. Mandible detached. (No. 17799, Coll. U. S. Nat. Mus. "La Havre Banks, U. S. F. Comm. Schr. 'Grampus.'")

FIG. 8 Right lateral view of the skull, including mandible, of a specimen of *Puffinus borealis*; adult; nat. size. (No. 17769, Coll. U. S. Nat. Mus., Massachusetts, U. S. Fish Comm.) Mandible articulated and held *in situ* by its dried ligaments.

FIG. 9. Right lateral view of the skull and detached mandible of a specimen of *Puffinus creatopus*; adult. (Coll. U. S. Nat. Mus., No. 18773.)

FIG. 10. Right lateral view of the cranium of an adult specimen lacking the mandible, of *Æstrelata lessoni*. (Coll. U. S. Nat. Mus. No. 14494, Kerguelen Island. Dr. Jerome H. Kidder, U. S. N., collector.) Quadrates and pterygoids missing; margin of lacrymal shaved off, otherwise quite perfect.

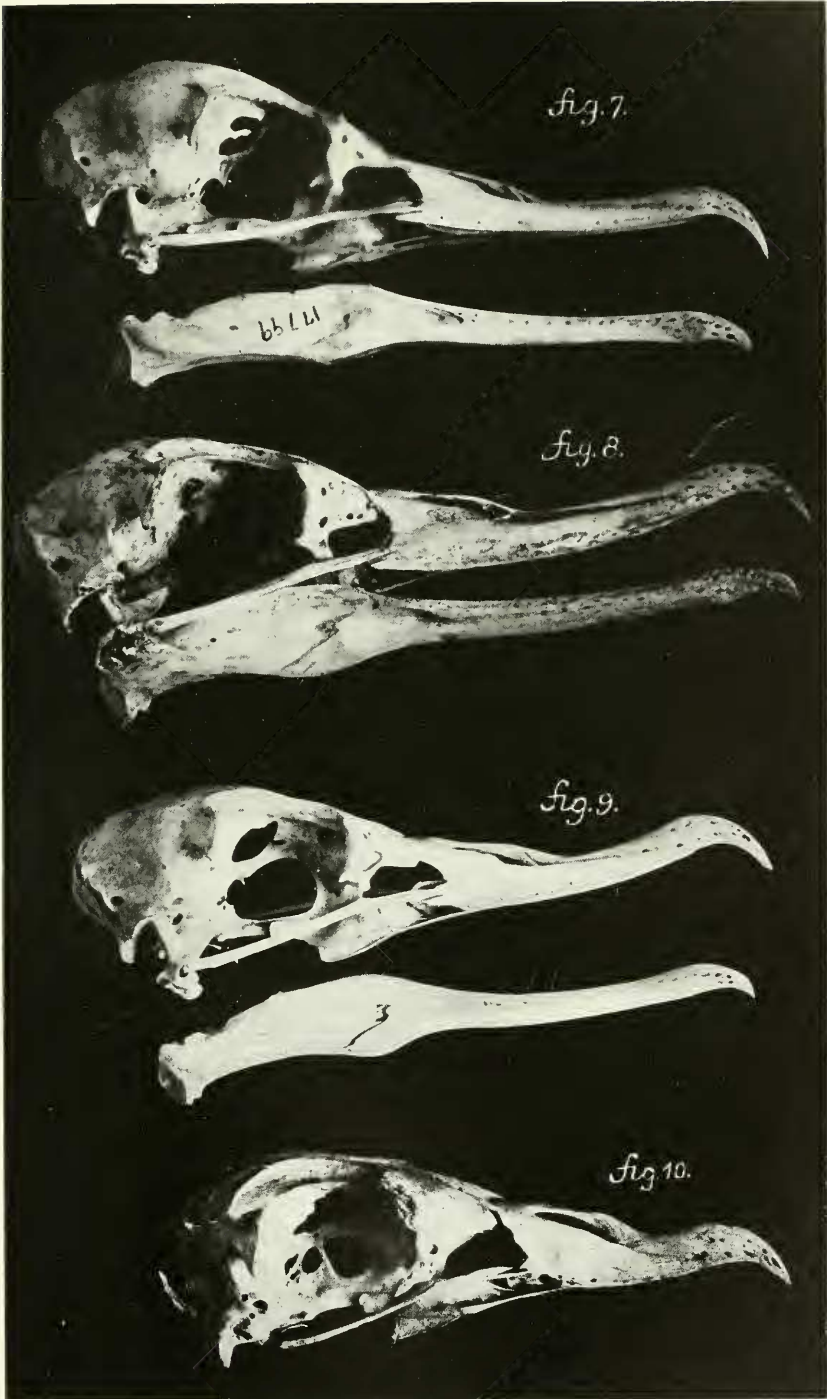


PLATE XVIII.

FIG. 11. Right lateral view of the skull and detached mandible of an adult specimen of *Daption capense*; nat. size. Coll. U. S. Nat. Mus. No. 18210 ("*Daptium capense*").

FIG. 12. Superior view of the skull of *Æstrelata lessoni*; same specimen as shown in fig. 10, Pl. II; nat. size; mandible missing.

FIG. 13. Direct ventral view of the sternum *Daption capense*. Belonged to the same individual which furnished the skull shown in fig. 11 of this plate. Nat. size.

FIG. 14. Direct superior view of the cranium of *Puffinus major*; nat. size; mandible removed. Same skull as shown on Plate II, fig. 7.

FIG. 15. Direct basal view of the cranium of *Puffinus creatopus*; mandible removed; quadrates, pterygoids and left lacrymal missing. Same specimen as shown on Plate II, fig. 9; nat. size.

FIG. 16. Superior view of the cranium belonging to a skeleton in the collection of the U. S. Nat. Mus., labeled "*Puffinus obscurus*"; nat. size; mandible removed. Same specimen as is shown in Plate I, fig. 6.

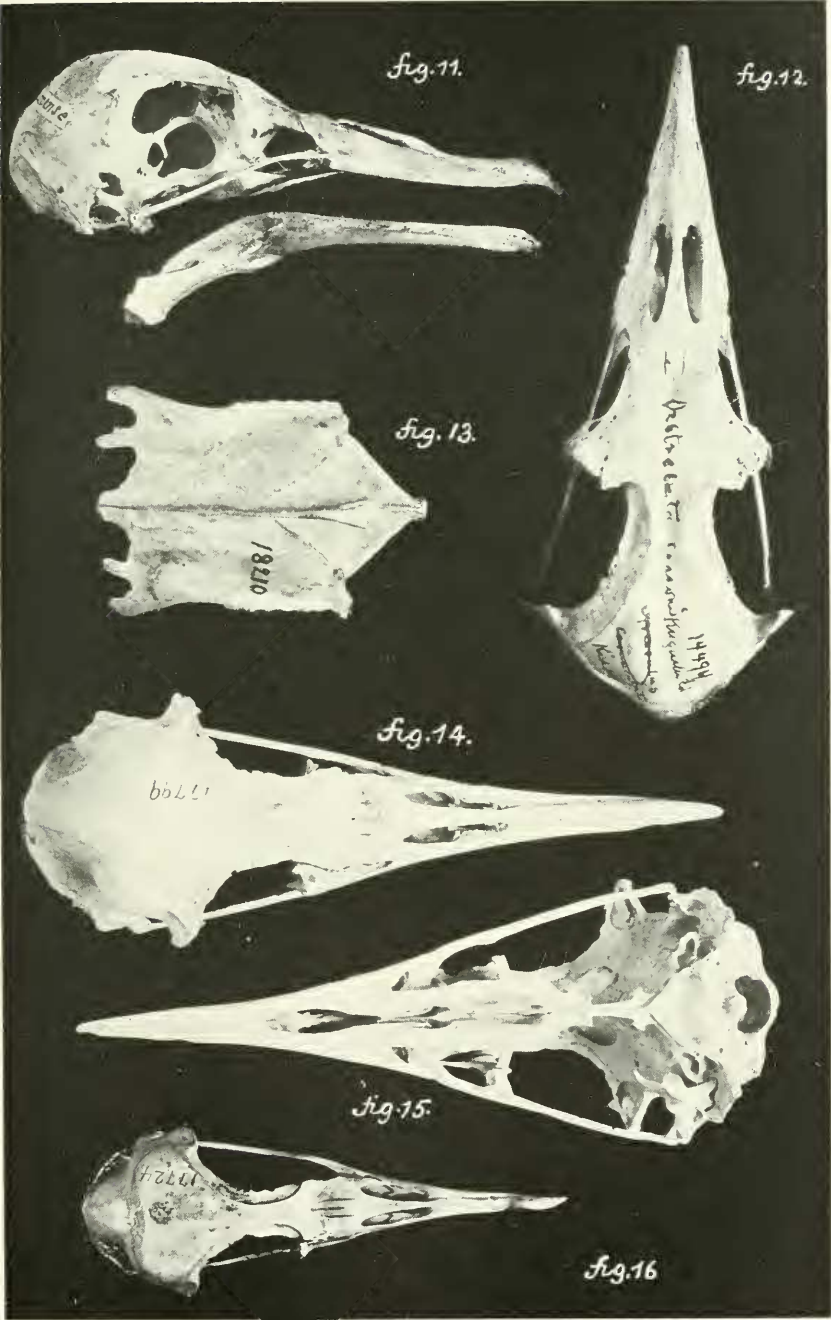


PLATE XIX.

FIG. 17. Direct left lateral view of the skeleton of a specimen of *Procellaria cooki*; adult; nat. size. Coll. U. S. Nat. Mus., No. 18285. ("Great Barrier Island.") Hyoid bones, with right pectoral and pelvic limbs detached.

FIG. 18. Bones of the lingual apparatus (hyoid bones) belonging to the skeleton shown in fig. 17 of this plate; nat. size; viewed from above (dorsal aspect). Glosso-hyal slightly detached.

FIG. 19. Anconal aspect of the skeleton of the right pectoral limb of the skeleton of *Procellaria cooki* shown in fig. 17 of this Plate. Nat. size, and bones normally articulated.

FIG. 20. Mesial aspect of the skeleton of the right pelvic limb of *Procellaria cooki*; nat. size, with the bones normally articulated. Belongs to the skeleton shown in fig. 17 of this plate.



fig. 18.

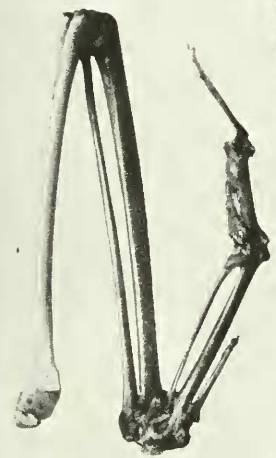


fig. 19.



fig. 17.

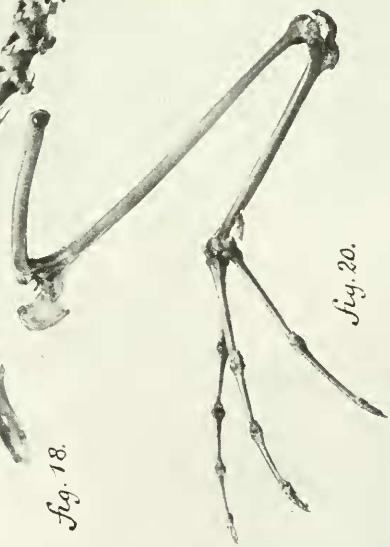


fig. 20.

PLATE XX.

FIG. 21. Left lateral view of the skeleton of a specimen of the "Diving Petrel" (*Pelecanoides urinatrix*). Adult; nat. size. Coll. U. S. Nat. Mus., No. 18771. Taken in New Zealand waters by Mr. C. F. Adams. Right pectoral and pelvic limbs detached; also the hyoid arches. Trunk skeleton partially rotated, admitting of a view of the anterior of the pelvic basin. Nat. size.

FIG. 22. Bones of the *hyoid arches* seen upon dorsal aspect. Belong to the skeleton shown in fig. 21 of this plate. Nat. size, and normally articulated.

FIG. 23. Skeleton of the right *pectoral limb* of the same specimen shown in fig. 21. Ventral view; nat. size.

FIG. 24. Skeleton of the right *pelvic limb* of the same specimen shown in fig. 21; mesial aspect; nat. size, and normally articulated.

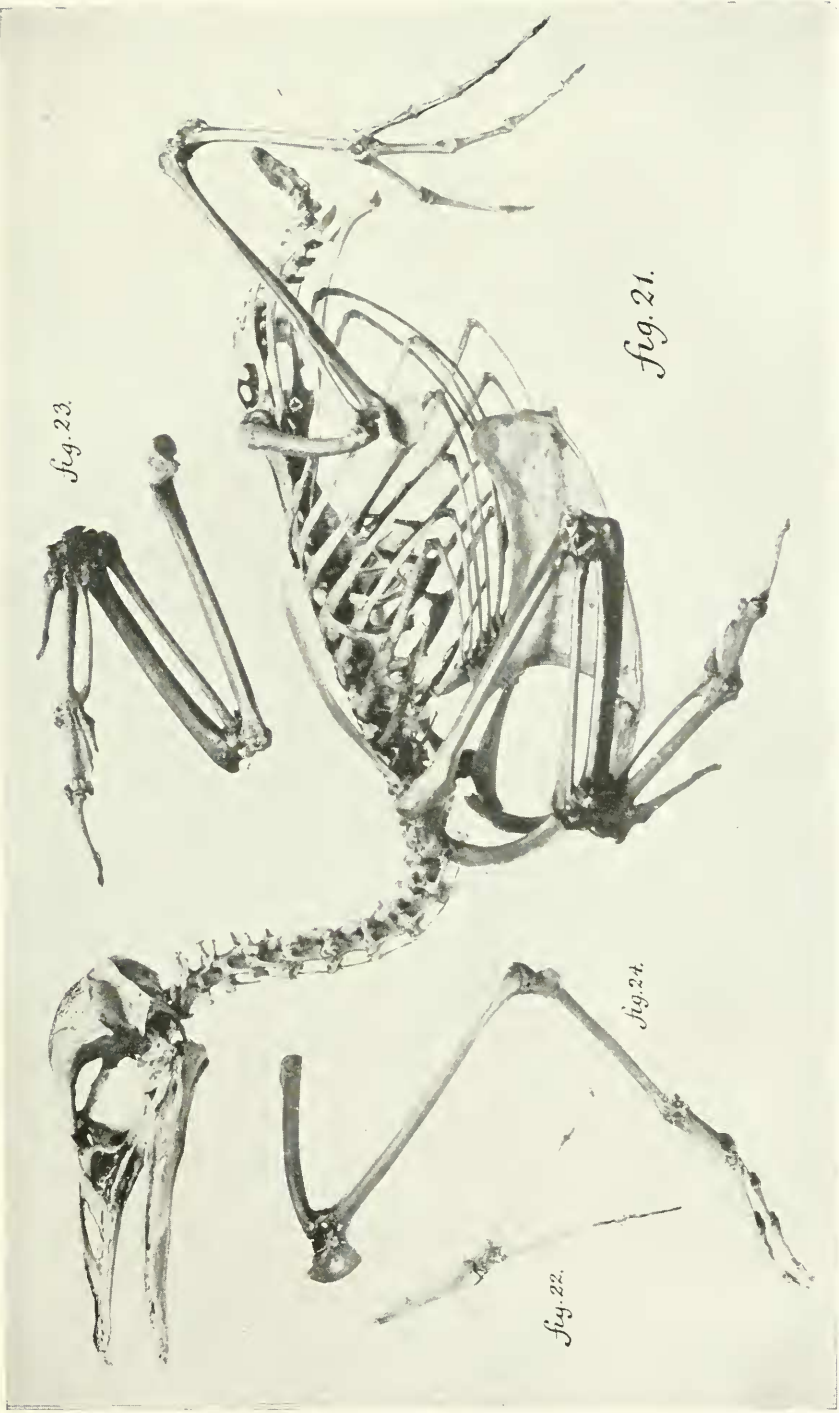


Fig. 23.

Fig. 21.

Fig. 24.

Fig. 22.

PLATE XXI.

FIG. 25. Right lateral view of the trunk skeleton of a specimen of *Puffinus borealis*; adult; nat. size. No. 17769, Coll. U. S. Nat. Mus. (Massachusetts, U. S. Fish Comm.).

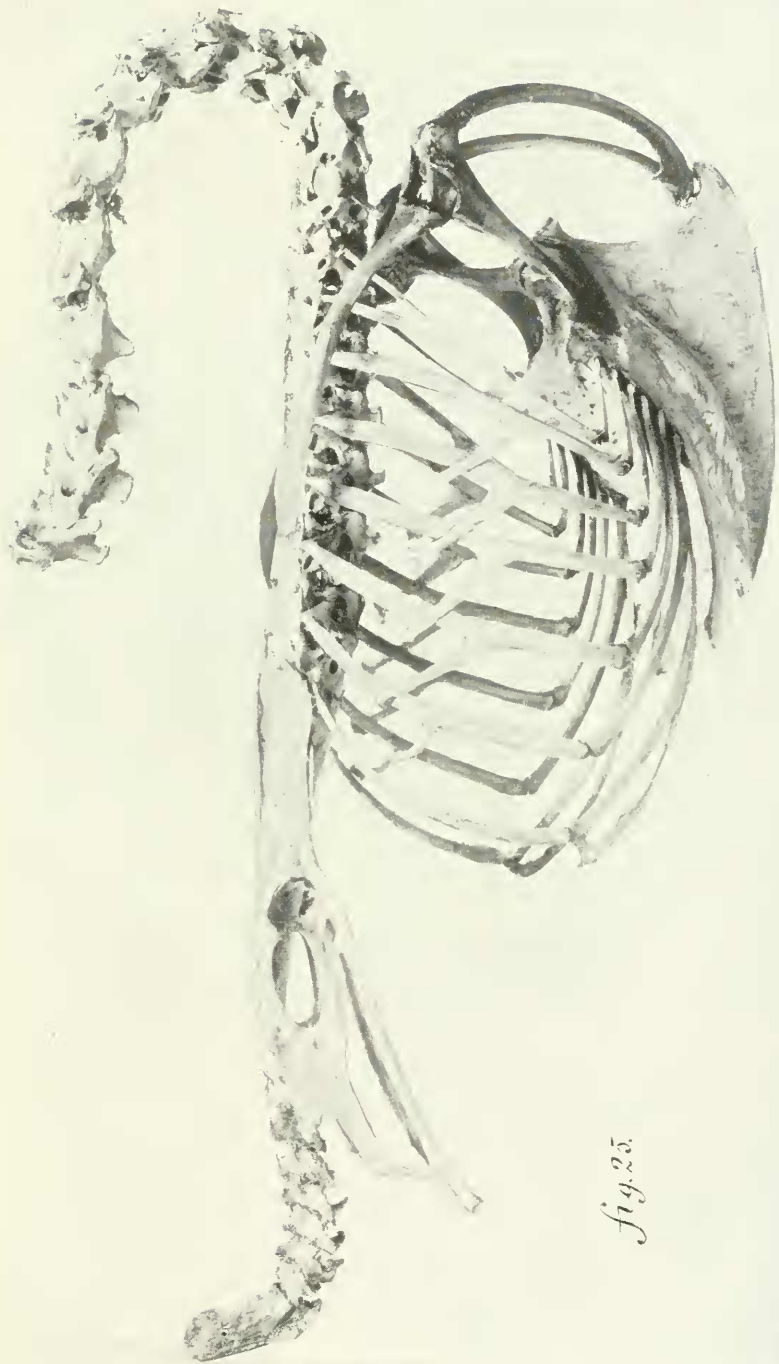


fig. 25.

PLATE XXII.

FIG. 26. Ventral aspect of the sternum of a specimen of a "Cahow"; adult; nat. size. McGall collection.

FIG. 27. Ventral aspect of the sternum of another specimen of the "Cahow"; adult; nat. size. Collection of Mr. Edward McGall.

FIG. 28. Ventral aspect of the sternum of a specimen of the skeleton in the U. S. Nat. Mus., Division of Birds, labeled: "*Puffinus obscurus*" (No. 17724). Same individual as the one in which the skull is figured on Plate I., Fig. 6. There is a pathological condition present on the left side of the body of this sternum, next to the keel. It was healed at the time the bird was taken, and was either due to disease or a punctured wound. Nat. size.

FIG. 29. Direct ventral view of a sternum of *Puffinus mcgalli* in the McGall collection (Subfossil, Bermuda). Nat. size, and from an adult bird. (See description in the text.)

FIG. 30. Direct ventral view of the sternum of *Daption capense*. No. 18210, Coll. U. S. Nat. Mus.; nat. size.

FIG. 31. Ventral view of the sternum of a specimen of *Puffinus gavia* (No. 18286, Coll. U. S. Nat. Mus. "*Puffinus gavius*," Barrier Island, F. F. Cheeseman, Auckland Museum).

FIG. 32. Right lateral view of the sternum of a specimen of the "Cahow"; nat. size. McGall collection.

FIG. 33. Ventral view of the sternum of a specimen of "*Puffinus obscurus*"; collection of C. J. Maynard. Bones of pectoral arch articulated *in situ*; adult; nat. size. Some of the costal ribs still attached. See description in text.

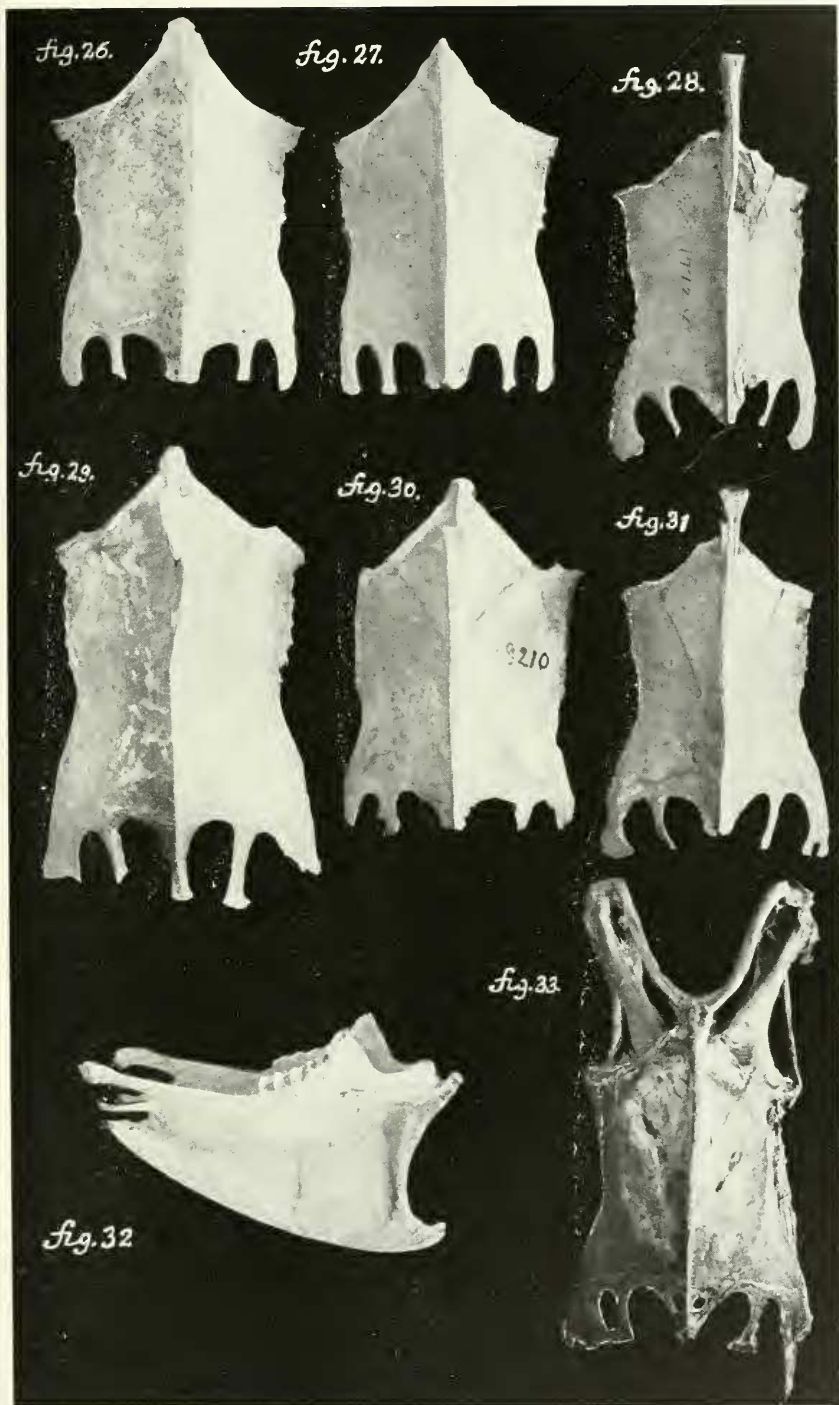


PLATE XXIII.

FIG. 34. Left lateral view of the sternum of "*Puffinus obscurus*," with shoulder-girdle articulated *in situ*; nat. size; adult. (See fig. 33, Pl. VII.) From the collection of C. J. Maynard.

FIG. 35. Right lateral view of the sternum of the bird's skeleton, labeled "*Puffinus obscurus*" in the collection of the U. S. Nat. Museum (No. 17724); adult; nat. size. See fig. 28 of Plate VII. (The hole in the keel was made in that a label might be attached to the bone—a procedure not to be recommended.)

FIG. 36. Direct left lateral view of a sternum of *Puffinus mcgalli* in the McGall collection (Subfossil, Bermuda cave). Nat. size; adult. (See fig. 29, Pl. VII, and the description in the text.)

FIG. 37. Left lateral view of the sternum of an adult specimen of *Daption capense* (No. 18210, Coll. U. S. Nat. Mus.). Nat. size. (See fig. 30 of Plate VII.)

FIG. 38. Ventral view of the sternum of a specimen of *Puffinus major*; adult; nat. size. No. 17799, Coll. U. S. Nat. Mus. La Havre Bank, U. S. F. C. Schr. "Grampus." Compare with the sternum next to it on this plate (fig. 39), which also belonged to a specimen of *Puffinus major*.

FIG. 39. Direct ventral view of the sternum of a specimen of *Puffinus major*; adult; nat. size. No. 18076, Coll. U. S. Nat. Museum (Off Cape Race, N. F. "Grampus.") Compare with fig. 38 of this plate.